THE *Petroleum* Engineer — Combined Edition

*Exploration—Drilling—Producing* • *Refining and Petrochemical* • *Oil and Gas Pipelining*
AND NATURAL GASOLINE

APRIL, 1954 • VOLUME XXVI • NUMBER 4

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# A Reason for Satisfaction

With talk in general business circles of mild recession, adjustments, and the like, the petroleum industry has reason to view its position with some degree of satisfaction. True, there are, have been, and will continue to be problems, but, without assuming an attitude of smugness, it can be said that this industry is less susceptible to general business recessions than many. In substantiation is the fact that since 1920 domestic demand has declined from the previous year in only five instances. Further, it is estimated that gasoline demand during the current year will increase from 3.6 per cent to 5 per cent, distillate sales will be 10 per cent greater, and crude oil demand will be about 4.2 per cent more than in 1953.

The anomaly of oil's position with respect to other businesses lies in the essentiality of petroleum products in our highly industrialized and motorized economy. But crude petroleum is of restricted value, so we should like to say a few laudatory words about the refining industry, the progress it has made, and the progress it will yet make. It should not be overlooked either that nowadays when one considers the refining industry he must combine it with that associate — petrochemicals.

Expansion in plant capacity and investment within the last several years has been remarkable. When the Petroleum Administration for Defense decided in 1950 that capacity increases in excess of current consumption were needed as a part of the defense program, the goal for the end of 1953 was 8,000,000 bbl a day. This objective, an increase of 1,100,000 bbl a day over December 1950 when the program was outlined, has been reached. Subsequent studies established the need for additional capacity increases, 400,000 bbl a day for 1954 and 250,000 bbl a day for 1955, a total of 8,750,000 bbl a day of domestic refining capacity by the end of that period.

A program for increasing the capacity of natural gasoline plants has as its aim the construction of 120,000 bbl a day in 1954 and an equal volume in 1955, which will bring the domestic total to 1,280,000 bbl a day by the end of 1955.

At the end of 1953, investment in petrochemical plants was $3 billion and it is estimated that in the next six years this figure will be $5 billion.

It has been said that probably the most significant trend in the oil industry has been the upgrading of product values. By means of new and improved refining processes improvements have been made in all standard products — motor fuels, lube oils, greases, etc. New products now available through petrochemical synthesis are legion. Plastics, insecticides, fibers, and hundreds of other products are commonplace today.

New markets have been developed in industry by the manufacture of special products such as waxes, cutting oils, refrigeration oils, and the like.

These few observations summarize only briefly some of the aspects of the oil industry that relate to refining and petrochemical processing, which have become so highly scientific and productive that 90 to 95 per cent of each barrel of crude oil is now marketable.

There is an aged remark that the meat packers utilize every part of a hog but the squeal, and it appears that the petroleum industry now approximates that status. The "squeal" has to do with the utilization of materials that formerly were wasted, or used as plant fuels or otherwise in applications at values far below their normal or possible economic worth. Much of the improved economy of modern refining is summed up in the conversion of "waste" materials to premium products such as olefins (ethylene, propylene, butylenes). Olefins are polymerized to make motor and aviation fuels of greatly increased octane ratings. Iso-paraffins are alkylated to aviation super-fuels. Refinery olefins are polymerized to resins, synthetic rubber, plastics, and petrochemicals without number. Acetylenes, diolefins, fabric intermediates (terylene from p-xylene, adipic acid), all the amazing intermediates dear to the economic heart of both the petroleum and chemical industries, are utilized to make premium products.

The number is legion, and the family is increasing faster than the imagination of man can follow.—*Frank H. Love.*

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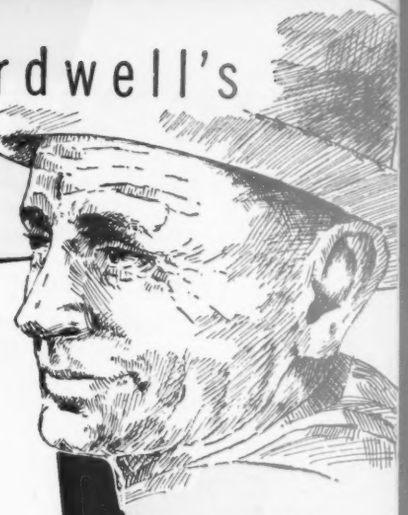

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Until a few weeks ago, both of these rigs have been on deep workover jobs in South Louisiana, on depths ranging from 8,000 feet to 13,000 feet. Most of the wells have been old ones which had very old tubing in them, this meant that we had to make many round trips during fishing operations. In most cases we then picked up 2 - 7/8" drill pipe to complete the workover job. We feel that this type of operation has given these rigs a real test.

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# HIGHLIGHTS ★ ★ ★

*Digest of News and Comment*

### Jet Fuel for Military

The military will buy 83,000,000 bbl of jet fuel in the year beginning July 1, an increase of nearly 80 per cent over current year's jet fuel purchases. This was revealed by Colonel Douglas Brown, chief of Armed Services Petroleum Purchasing Agency, to National Petroleum Council. The amount will reach about 230,000 bbl daily. Brown also reported military demands for grade 115/145 aviation gasoline will show slight increase.

★ ★ ★

### Oil Demand Rise Seen

Tourist season will bring better prices for gasoline as wholesale dealers buy up stock to meet spring-summer demands, Paul Endacott, Phillips Petroleum president, predicted. K. S. Adams, Phillips chairman, added oil consumption in U. S. will increase about 5 per cent this year over last instead of 3 per cent generally estimated. Gulf Oil officials foresaw increase of 2 to 4 per cent in oil demend.

★ ★ ★

### Cuba Urges Drilling

Cuba will match dollar for dollar with any company who will drill in that country. It stressed it was not willing to match expenses for exploration work; the country will provide equal amount of capital as spent by the operator for drilling.

★ ★ ★

### Wafra Crude in Texas Port

First cargo of crude oil from Wafra field in Kuwait Neutral Zone has been brought to Houston, Texas. Cost of oil from this latest field to enter world markets is not known, but rumors say it is below similar gravity oil from West Texas via pipe line. Owners of Wafra crude are Pacific Western and American Independent (Aminoil), made up of Phillips, Hancock, Signal, Ashland, Sunray, Deep Rock, Globe, Lario, J. S. Abercrombie, R. K. Davies.

★ ★ ★

### Texas Produces More Oil

*Texas is producing more oil this month than last — a total of 3,104,568 bbl. Texas Railroad Commission has granted oil producers an increase of 73,205 bbl daily over the March allowable of 3,031,363 bbl. Raise followed reports from major oil companies that gasoline stocks were not excessive.*

### Gas Turbine Auto Engine

Although it may be some time before the modern gas turbine automobile engine becomes common usage, Chrysler Corporation is attempting to iron out some of the problems involved. Two main drawbacks are high consumption of fuel and hot blast from exhaust, both of which Chrysler claims to have solved in a test engine.

★ ★ ★

### Oil Use Up Per Capita

Use of petroleum products has been increasing 4 per cent per capita, J. C. Donnell, II, Ohio Oil president, reported. This coupled with anticipated growth of population will greatly effect further expansion in the use of oil and its products, he emphasized. U. S. demand for oil in last 7 or 8 years has increased more than 350,000 bbl per day annually, he reported.

★ ★ ★

### Wants Division

*Oil companies cannot legally own interstate pipe lines, if a bill introduced by Senator Gillett (D, Iowa) becomes law. It would put oil common-carrier pipe lines under 1906 Hempburn Act, which prevents railroads from transporting in interstate commerce any commodity mined or produced by them or in which they own an interest.*

★ ★ ★

### IOCC Oil Booklet

A concise and thorough explanation of oil and the industry is contained in Interstate Oil Compact's latest booklet "Oil for Today and Tomorrow." It is designed for non-technical readers, and deals with origin, production, conservation, and importance of oil and gas. It is another one of the Compact's fine contributions to the industry.

### Hallanan Renamed Head

Walter S. Hallanan, Plymouth Oil Company, has been named chairman of National Petroleum Council for the eighth time. "Independence and freedom of action" within Council's sphere is responsible for its contribution to national welfare, he stated in accepting this new office for a new term. Other officers are R. G. Follis, Standard of California, vice chairman, and James V. Brown, secretary.

★ ★ ★

### Competitive Discounts

*Special competitive allowance of 1.55 cents a gallon off tankwagon price of gasoline have been granted dealers in northern New Jersey by Sun Oil. Allowance was granted after dealers reported prices were not competitive.*

★ ★ ★

### Egypt Buys Red Oil

Egypt plans to buy some 15 per cent of its required oil from Russia. An agreement was signed whereby it will buy about 50 per cent of its kerosine and 75 per cent gasoline needs from Romania, with the first consignment due in Egypt the last of March.

★ ★ ★

### Paper on Imports

A group of staff papers, including one on oil imports, has been made public by Chairman Randall of the President's Commission of Foreign Economic Policy. Paper gives arguments for and against high imports.

Argument against higher imports pointed out tendency of crude supply to outrun domestic demand. Case for continuing high-level imports is long-range conservation of nation's resources and preparation for time when "current supplies may be inadequate."

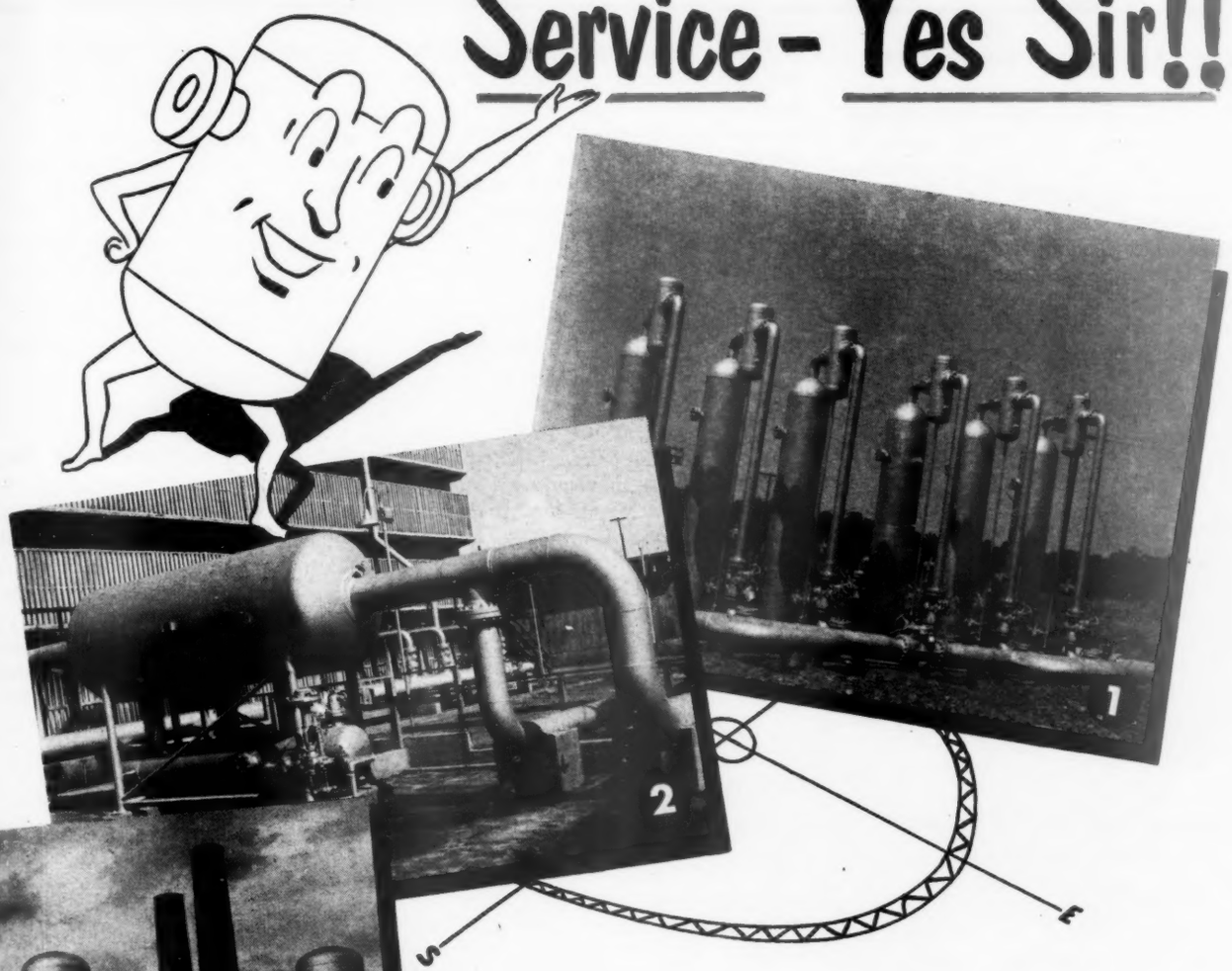
### Oil-Gas Reserves for 1953 Highest in History

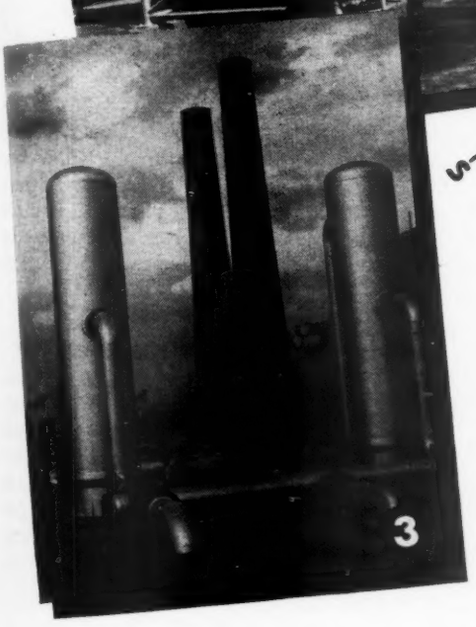
Record high oil and gas reserves for 1953 were reported by American Petroleum Institute and American Gas Association. Following is summary of report:

| Reserves | Dec. 31, 1952 | Dec. 31, 1953 | Increase 1953 over 1952 |
|---|---|---|---|
| Crude oil, bbl | 27,960,554,000 | 28,944,828,000 | 984,274,000 |
| Natural gas liquids, bbl | 4,996,651,000 | 5,437,922,000 | 441,271,000 |
| Total hydrocarbons | 32,957,205,000 | 34,382,750,000 | 1,425,545,000 |
| Natural gas, cu ft | 199,716,225,000 | 211,447,132,000 | 11,730,907,000 |

| Production | 1952 | 1953 | Increase 1953 over 1952 |
|---|---|---|---|
| Crude oil, bbl | 2,256,765,000 | 2,311,856,000 | 55,091,000 |
| Natural gas liquids, bbl | 284,789,000 | 302,698,000 | 17,909,000 |
| Total hydrocarbons | 2,541,554,000 | 2,614,554,000 | 73,000,000 |
| Natural gas, cu ft | 8,639,638,000 | 9,238,540,000 | 598,902,000 |

# Service - Yes Sir!!




1 Photo showing Peerless Line Separators at Pipeline Station in Oklahoma.

2 Peerless Horizontal Separator handling 240,000,000 cu. ft. per day, while removing condensed liquid from cooling tower, at plant in California.

3 Two Peerless Vertical Scrubbers at a power plant in South Texas, each handling 50,000,000 cu. ft. of gas per day.

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# HIGHLIGHTS—2

### NPC Structure Defended

National Petroleum Council is having to defend its unique setup, after other industries were turned down in an attempt to set up similar councils. Chief features of NPC are: It has its own chairman, sets its own agenda, and has relative freedom from government control. Department of Justice, told other councils that general policy is for advisory groups to have government chairmen, and Interior officials now indicate they feel other industries should have same type of council or that petroleum should lose its special type.

★ ★ ★

### Carter Earnings Up

Carter Oil has reported a total of 56 wildcat wells drilled last year, more than were drilled by any company in 27-state area in which it operates. A total of 19,500,000 bbl of oil were produced by Carter, whose net earnings were $9,700,000 up $2.9 from the year before.

★ ★ ★

### Turkey Oil Act Passed

*Turkey has denationalized her petroleum resources and opened the way for development by foreign companies. New law enacted was written by Max W. Ball, U.S. petroleum lawyer, some time ago. Aim is to promote rapid development of oil production in the country by offering financial and other inducements to foreign companies applying for exploration rights.*

★ ★ ★

### Lower Depletion Tax

Oil men should be on the lookout for new attempts to lower the tax depletion allowance, Russell B. Brown, Independent Petroleum Association, warned recently. He referred specifically to an amendment sponsored by Senators Williams of Delaware and Aiken of Vermont, Republicans, which asked for an allowance cut from 27½ per cent to 15.

★ ★ ★

### Oil Import Level

American oil industry has been warned by the State Department to keep oil imports at present levels. Warning was issued by Herbert Hoover, Jr., special consultant to Secretary of State. Key man in attempting settlement of Iranian question, Hoover told six leading oil industry spokesmen recently that Iranian oil must get back in free world markets or go to Soviet. He said settlement was near, but not final, and that U.S. oil companies helping to run the Iranian industry must restrain lest they bring in too much oil into U.S. He added if imports go beyond present levels, pressure for a quota ceiling by legislation may become too strong to resist.

★ ★ ★

### Soviet Oil in Germany

*Sale of $5,000,000 worth of Russian oil in Western Germany has been tentatively negotiated for, Uniti, official organ of German Wholesale Petroleum Dealer's Union in Hamburg, has reported. This is first substantial entry of Soviet oil into this market since the war. Deliveries are to take place over an unspecified 12-month period. Amount of oil involved is about 5 per cent of quantity West Germany imported from the U.S. and sterling oil companies last year.*

★ ★ ★

### Fights Gas Regulation

The fight against a bill giving states power to regulate sale of natural gas is still on in the opinion of Senator Douglas, Democrat from Illinois. Already approved in the House and with wide support in the Senate, the bill would give state utility commissions exclusive authority in regulating rates of companies selling gas within its borders. FPC now shares that authority. Douglas argued state regulatory bodies more often than not permit gas and electric companies to boost rates.

★ ★ ★

### Billion Dollar Expansion

Standard Indiana and its subsidiaries announced a two-billion dollar expansion and modernization program that will cost about half a billion dollars. Almost half that amount will go into development of new crude oil production and reserves. In making announcement, Chairman Robert E. Wilson said company activities in 1953 showed gains in most every department; net earnings were $124,826,397.

**W. H. Pinckard** was listed as president of The California Texas Oil Company, Ltd., on page A-18 of the March issue of *The Petroleum Engineer*. His title should have been chairman of the board of this company.

### Tidelands Act Upheld

Alabama and Rhode Island have been denied permission to challenge constitutionality of controversial offshore oil act by the Supreme Court, who thereby upheld the act. Some members of Congress foresaw court battles, however, predicting that more dissention would come when boundary lines are finally drawn. The high court ruled that power of Congress to do as it saw fit with public lands "is without limitation."

★ ★ ★

### Derby Sponsors Oil Meet

Members of the American Farm Bureau gathered at Oklahoma A & M College, Stillwater, recently, where Derby Oil Company sponsored a demonstration and lecture covering the oil industry. F. W. McCurry, Derby's vice president in charge of manufacturing and research, used a miniature producing, transportation, and refining exhibit to cover operations of the industry from origin to consumption.

★ ★ ★

### Lower Imports Reported

Standard of California has announced lower imports for second quarter this year. West Coast imports total 10,000 to 12,000 bbl below January-February levels, bringing Standard's import rate to about 23,000 bbl daily. Second quarter rates will be about 35,000 bbl below 1953 period.

★ ★ ★

### Economical Synthetic Oil

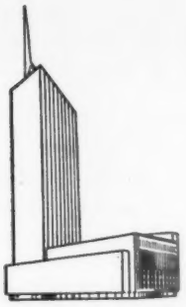
New strides are being taken in economical production of synthetic gasoline and other fuels, according to Louis C. McCabe, head of fuels and explosives division, Bureau of Mines. McCabe reported that research on a 450 psi gasifier that will lower cost of synthetic fuel production is considerably advanced.

★ ★ ★

### Oil Men Out of Deal

Saskatchewan has claimed a share in profits from the Smiley oil field, biggest strike in the province. The socialist government reported an agreement was completed with a co-operative granting development rights to crown oil reserves in the Smiley district. Agreement by-passes private companies whose investments in oil development run in the millions of dollars. Province's share under agreement is 15 per cent until the co-operative regains its investment, rising to 60 at that time.

## *What does it take to build an "Oil Bank"?*



### CONSTRUCTION

It takes facilities—a lot of them—to serve the financial needs of oil production. Look at the Dallas skyline and you'll see them — 40 stories, including 4 basement levels... big enough and broad enough to serve Texas' biggest industry.

### PRODUCTION

Oil production — 4,171,700 barrels of it every day — is the cornerstone of Southwestern prosperity. It takes money to keep it humming. Supplying that money is what it takes to make an "Oil Bank."

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# Petroleum Profile

KENNETH G. MACKENZIE

TWO principles basic to the intellectual and emotional make-up of Kenneth G. Mackenzie, one of the most widely known men in the petroleum industry, might best explain the dynamic vigor and multifarious activities of the man: "My vocation," he says, "is my company; my avocation is my industry." Mackenzie recently retired as assistant to the vice president, refining department, after more than 42 years with The Texas Company.

Born in New York City in 1887, he has lived in Westport, Connecticut, since he was four. On his retirement from The Texas Company, he is setting up a consulting office there as well as one at 9027 S. Damen Avenue, Chicago, Illinois. At 20, he was graduated with a Bachelor of Philosophy, from Sheffield Scientific School of Yale University, became an instructor there, received his Master of Science degree in 1909 when he quit teaching.

Mackenzie was briefly a research chemist at New York testing Laboratory of Barber Asphalt Paving Company and chief chemist for the Nairn Linoleum Company. In 1911, he moved to The Texas Company where his career ranged from consulting chemist to assistant to the vice president in charge of refining and chief technologist. Other positions he held were: Manager of technical division, refining department and vice president of Texaco Development Company; founder and chairman (29 years) of Texaco's Technical Advisory Committee to Texas' Manufacturing and Marketing Committee.

Member of the ASTM Committee D-2 on Lubricants in 1912, he was its secretary for 9 years and its vice chairman for the next 8 — until 1930, when he became president of the Society.

Since 1916, as a member of the Committee on Science and Arts of the Franklin Institute, he has participated in recommendations for award of the Institute's medals, such as for the Franklin Medal, international award next to the Nobel Prize in prestige.

Pursuing his avocation avidly, the good of the petroleum industry, he pushed his "damn desire to get hold of things" by furious activities in technical circles, a pursuit which did not limit his quest for a rare erudition that is familiar with the more obscure works of Jefferson, the humor of Mark Twain and the convoluted writings of Gertrude Stein — whom he reads as a soporific.

In the middle 20's, he joined the Lubricants Division, SAE, and its successor, Fuels and Lubricants Technical Committee. He helped prepare the original SAE Classification of Viscosity Numbers and is accountable for the present revised classification.

His persistent desire to see the closest cooperation between the automotive and petroleum industries urged him on to tread on many an obstructive toe in trying to solve their mutual problems. In 1933, the API organized a committee to this end. In 1941, in spite of opposition, he eventually got a $25,000 appropriation for an automotive engineer whose prime function was to solve petroleum-automotive problems.

This move eventually resulted in the formation of the Co-ordinating Research Council, jointly sustained by the API and SAE; Mackenzie was first the API representative, later a director and chairman of its Finance Committee.

As one of three American representatives, he served until this year on the Permanent Council of the World Petroleum Congress, and he is still the Council's Secretary.

During the last war, he organized and was secretary to the Technical Advisory Committee to the War Council that pooled research data on butadiene and aviation gasoline components.

Mackenzie also was a member of the Council of the ACS and of the Executive Committee of the American Section of the Society of Chemical Industry of Great Britain.

In the API, he was a member of the General Committee, Refining Division; a charter member and part-time chairman of both the Committee on Methods of Test and Specifications and the Program Committee until 1954; a member of the Automotive Survey Committee and chairman of its successor, the Automotive Research Committee until 1953; from 1949, he has been chairman of the Subcommittee on Publicity of the Program Committee, Refining Division, API.

The citation accompanying one of the first three Certificates of Appreciation awarded to Mackenzie by the Division of Refining, API, characterizes Mackenzie as follows:

"His natural and acquired endowments, among which are a brilliant mind, limitless vigor, extensive knowledge, keen foresight, scintillating wit, and prodigious memory, have been devoted without stint to the affairs of the refining branch of the petroleum industry before and since the American Petroleum Institute was organized."

# How to Assure Low-Cost Steel Valve Service ...in Hot Oil Handling, for example

THE INSTALLATION

In the world's largest natural gasoline and gas cycling plant at Katy, Texas, with Crane steel gate valves on absorption oil heater lines. Working pressure, 160 psi, 520 deg. F.

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| SUITABILITY: | Fully effective |
| FEATURES: | Crane Exelloy Trim |
| MAINTENANCE COST: | Nil—routine care only |
| SERVICE LIFE: | 10 yr. plus—prolonged life assured |
| OPERATING RESULT: | No shutdowns for valve trouble |
| AVAILABILITY: | Crane catalog item—No. 33X |

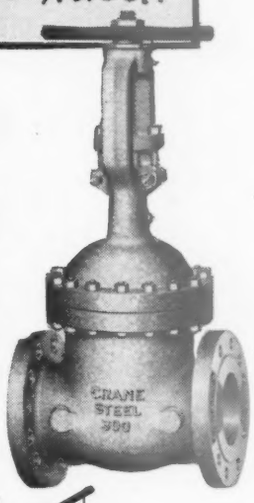
## THE CASE HISTORY

Installed as original equipment, these Crane No. 33X 10-inch gate valves have given continuous service since 1943. Year after year, they remain fully effective under severe conditions. They seat tightly with smooth, positive operation, yet with no maintenance other than periodic cleanout of accumulated oil sludge. Their Crane Exelloy seating surfaces show no sign of corrosive or erosive effects. They assure the plant of continued trouble-free, low-cost performance.

Obviously, valves that behave like this aren't bought on price alone. Quality is the first consideration. That's thrifty buying—the only way to get the best value.

## THE VALVE

It stands apart from ordinary performance because of pioneering skill in steel casting . . . leadership in design and manufacture . . . and complete suitability for petroleum industries' process and power service needs. Choose from the widest range of body and trim materials, in all pressure classes and sizes, with flanged, screwed, or welding ends. See your Crane Catalog or Crane Representative.

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# PETROLIC PERSONALITIES

DICK SNEDDON

## NEWS FROM NEW YORK AND LOUISVILLE

Today, at no extra cost, we are going to ramble hither and yon over the country, and present bits of intimate detail about a lot of interesting people. And who would be better to start with than Harry Bialock, president of John B. Astell and Company, Inc., New York, whose firm specializes in stainless steel pipe, tubes, fittings, and that sort of stuff. Harry used to be in charge of tubing specialties for National Tube division of U. S. Steel and is known from Maine to Monterey. In his spare moments he may ordinarily be found in his woodworking shop balancing the legs of a wobbly bridge table; at his workbench etching an artistic design on a leather handbag with a hot iron; or in his darkroom dabbling a roll of film in the fixing bath.

Then there is John Seiler, executive vice president of Tube Turns, Inc., Louisville, Kentucky, the slogan of which is "One Good Tube Turn deserves another." John has been with the firm for some 25 years and finds his diversion in cattle farming. It has nothing to do with the subject but we once knew a farmer who was such an atrocious liar that he had to get one of the neighbors to call his hogs.

## TAME GAME ON THE HACKER ESTATE

Next on the roster is Lou Harrison, the New Yorker who is manager of eastern sales for Ladish Company. Lou is a Brooklynite and proud of it. He is also a pretty sharp golfer, particularly if he is given enough strokes, and is a sharp enough gin rummy player to give his competitive strokes, apoplectic, that is.

Over in Houston, Texas, is a mighty little bundle of energy, Marshall "Pete" Peters, buyer of Humble Oil & Refining Company, who is a past president of the PA Association of Houston, loves to join impromptu quartets at oil men's whingdings, and is good company anywhere, even on the golf course.

Skipping now to Cudahy, Wisconsin, we find another consequential Ladish attache in the person of Joe Hacker, who hails originally from the home of the Green Bay Packers, was graduated at the appropriate time with an L.L.B. from Marquette University, was promptly thereafter admitted to the bar, and hasn't been in a bar since. Joe actually makes his home in Milwaukee, is a member of the Bluemound Country Club, and admits that his last name is pretty accurately descriptive of his prowess as a golfer.

## DANCING WITH TALL WOMEN RESTRICTS VIEW

Over in Pittsburgh is Dale Patrick, vice president of Pittsburgh Screw and Bolt Corporation, a native of McKeesport (The Steel Valley), a chem grad from Grove City College, and a popular member of the Shannopin Country Club. Dale is reputed to be one of the most feared bridge players in the state of Philadelphia, but we have been unable to find out yet whether he is feared by his opponents or his partner.

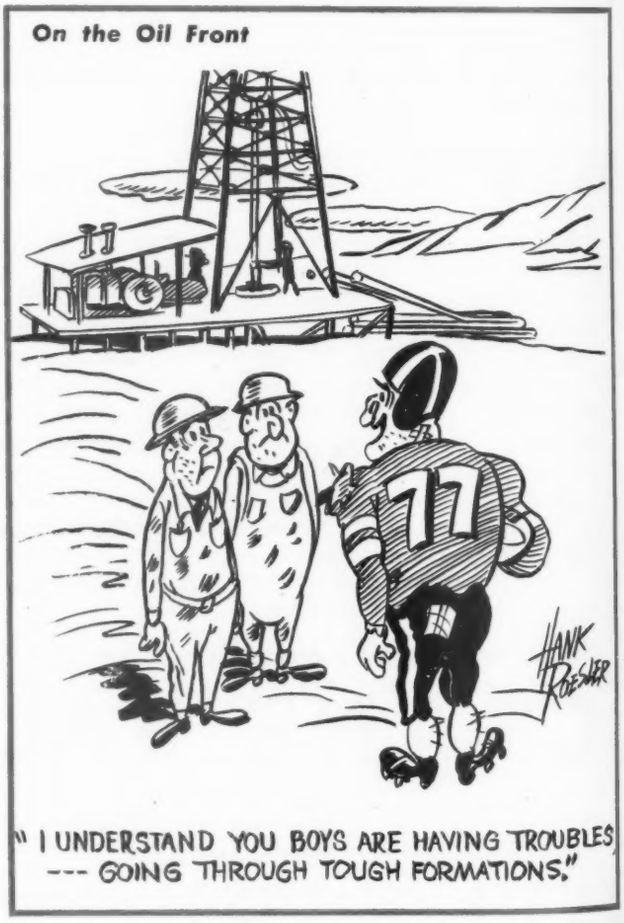
Backtracking to New York we introduce A. J. "Al" Yardley, president of Jenkins Bros., the noted valve manufacturers, who has had 20 years of diverse and altogether interesting experience with his company. Al likes hunting even when he is merely hunting a place to fish, but his principal extra-curricular excitement is really antiques of which we are told he has quite a collection.

Briefly to Chicago now for a minute with Ruddy Fritsch, general sales manager for Taylor Forge & Pipe Works, sometimes known as "Shorty." Rudy is very fond of fishing but tells us that his real hobby is a most unusual one—dancing with very tall women. Being ourself a bit under normal size and having tried that hobby we can say with conviction that the view is definitely restricted.

## THE WEST COAST AND WEST COASTERS

Down in New Orleans, Louisiana, is a well known chap, Hardy Klarquist, manager of purchasing and transportation for the California Company. Hardy is a native of Los Angeles where he began his oil career with Standard of California. Meantime he has traveled widely. He spent three years for Aramco over in Saudi Arabia garnering all sorts of information and experience, and had another three years overseas with the army which of, course, gave him an altogether different kind of experience.

Jumping all the way back to the West Coast now, we had a nice letter recently from Ralph Arnold, one of the most widely known geologists in the United States and, indeed in the world. Ralph has more honors conferred on him than Zulu chieftain and has garnered more degrees than a Fahrenheit thermometer. He has been having treatment in a Santa Barbara sanatorium for some time but is apparently recovering in good shape, at least he talks of drilling several wildcats in the next little while. Anyway, with his many friends, we wish Ralph a speedy return to his customary good health and vigor.



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**AMERICAN PIPE AND SUPPLY COMPANY**
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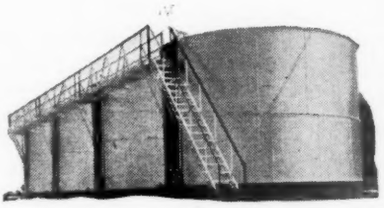

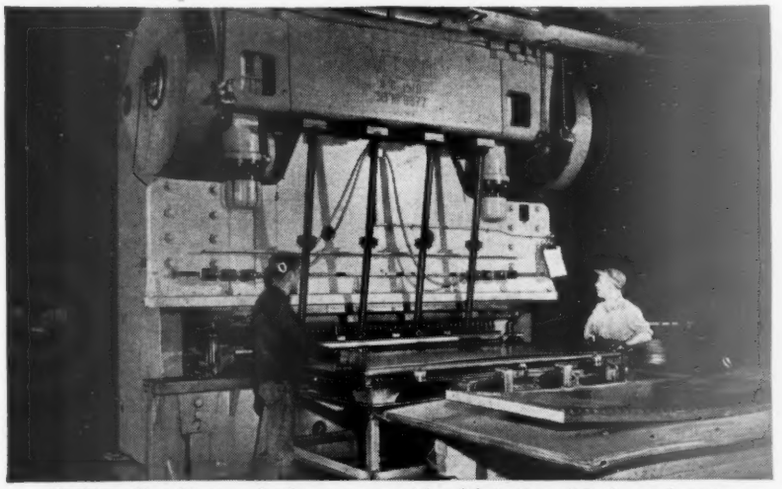

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# LETTERS ★

## Needs Petrochemical Reprints

*To The Petroleum Engineer:*

Please let me know if we may have permission to reprint and distribute copies of the article "Synthesis of Petrochemicals — Part 7" by Everett E. Gilbert in the February issue, Page C-21 of *The Petroleum Engineer.*

*J. O. Roche*
General Chemical Division
Allied Chemical and Dye Corporation

*To The Petroleum Engineer:*

Your article on the successful synthesis of acetylene which appeared in the January, 1954, issue was of great interest to us.

If reprints of this article are available, I would appreciate receiving one.

*John L. Bills*
Brea Chemicals, Inc.

## Remains Unconvinced

*To The Petroleum Engineer:*

Thank you for your letter of January 2 concerning your comparison of catalytic polyforming with catalytic cracking, as presented in your paper entitled "Catalytic Polyforming of Gas Oil" which appeared in the September 1953 issue of *The Petroleum Engineer.*

You will recall that in my letter of December 15, I pointed out that the octane ratings you obtained under "catalytic cracking conditions" were 6-10 units low. On rereading your article I see that my reference to a single catalytic cracking run was not correct and that the octane ratings you report are based on a number of runs. Apparently I put the emphasis in the wrong direction by referring to the scope of your data instead of pointing out the tremendous volume of data supporting my point. In our own laboratory we have carried out literally thousands of runs under fixed-bed catalytic cracking conditions in connection with our early development of the process and more recently in the testing of cracking catalysts. In all cases where a naphtha free gas oil has been used, octane ratings have ranged from 78-82 F-2 and 88-95 F-1. I am sure that many other laboratories have duplicated this experience.

For specific data, I refer you to the first article by Houdry et al (Refiner and Natural Gasoline Manufacturer, Vol. *17*, 574, Nov., 1938) in which one of the major points was that the F-2 octane number was 77-81 from any charge stock heavier than gasoline. It was stated that octane rating was not significantly affected by changes in boiling or type of crude. Research octane numbers were stated to be 7-10 points higher. Some of our own data bearing on this subject have been presented in a paper entitled "Silica-Magnesia Cracking Catalyst — Commercial Performance" (Chem. Eng. Prog., Vol. *46*, 176, April, 1950), a reprint of which is enclosed. Comparing Tables 2 and 5, you can see that the octane numbers obtained in the fixed-bed actually look better than fluid operation. We do not believe there is a significant difference, however, and attribute this result to the presence of naphtha in the feed to the fluid unit.

Thus, we see no noticeable difference in yield or octane number between fixed-bed and fluid catalytic cracking when carried out under the same conditions of feed stock, temperature, space velocity, and catalyst residence time. It was with this in mind that I quoted the article by Olson and Sterba on fluid operation since it contained a rather comprehensive study of the effect of reactor temperature and thus permitted closer comparison with your data.

All these data emphasize the fact that your octane numbers under "catalytic cracking conditions" are abnormally low and that some unusual factors must be responsible, such as excessive thermal cracking. I would strongly suggest that you carry out further catalytic cracking experiments at higher temperatures and short cracking periods to determine whether results more nearly typical of catalytic cracking can be obtained in your equipment. If the ratings are still low then it would be desirable to make some equipment revisions to bring the results in line. Once the catalytic cracking results are in line, repetition of some of your polyforming tests would then give a real evaluation of the advantages, if any, for this process. Since there is a good possibility that the factor causing low octane ratings under "catalytic cracking conditions" is also affecting your polyforming results, this work might conceivably show a real advantage for catalytic polyforming. I feel that this would be a much simpler and hence more fruitful approach than attempting to carry out catalytic polyforming in a fluidized system.

I will be interested in your reactions to the above discussion.

*A. L. Conn*
Director, Pilot Plant Division
Standard Oil Indiana
Whiting, Indiana

**Editor's Note: Above letter was addressed to Professor Lloyd Berg.**

## Liked Safety Editorial

*To The Petroleum Engineer:*

All of us are delighted with the splendid editorial in your December issue, Page D-3, and want you to know how much we appreciate it.

*Paul Jones*
Director of Public Information
National Safety Council

## Inspects Spearow Method

*To The Petroleum Engineer:*

Your article in the January issue by Ralph Spearow, Page B-39, *New Technique in Oil Production,* with reference to his method of producing at Osawatomie, Kansas, was very interesting and hundreds of operators have gone to inspect it including myself.

Give us some more like it.

*Hal H. Vaughan*
Shamrock, Texas

## Missed in East Texas

*To The Petroleum Engineer:*

I am very sorry to tell you that I will not renew my subscription. I have been taking far more oil papers, trade journals and business papers than I ever get to look at or read.

I am also leaving here for a long needed vacation.

I do not assume I will again be on your mailing list. In leaving you I regret it as much as you do, and I again want to congratulate you on putting out one of the very finest trade papers in the entire oil industry. I recently cancelled my subscription starting back about 1910 with the Oil and Gas Journal so I am not selecting your paper as one to be dropped but long ago started cancelling subscriptions that had run for years.

I wish you and Miss Adams the most wonderful luck in the world, you have a mighty fine city down there and I always enjoy my visit to your state and especially like visiting Dallas, Fort Worth, Wichita Falls, and Houston.

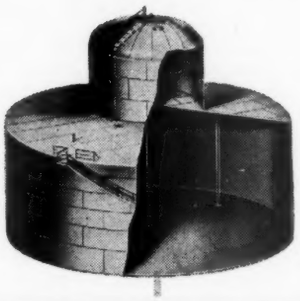
I think I am the only man in the lease or land departments who was in East Texas early in 1931 who did not come home with a few millions. However, I just happened to be tied up with too small a company at that time, and we also passed up the Fitts pool in Oklahoma that same summer of 1931.

That is the way the oil game runs, but I have been fairly lucky back in the east and would not trade my oil experiences and the friends I made all over the oil country for anything in the world.

The best of everything to you.

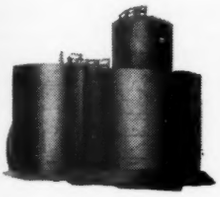
*H. P. McGinnis*
Tri State Tool and Supply Co.
Parkersburg, West. Va.

# the HAMMOND DIALIFT*

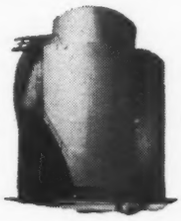


## MONEY SAVER FOR PRODUCT-STORAGE OPERATORS!

**The Hammond DIALIFT is the modern tank for eliminating breathing losses and reducing filling losses. It gives maximum conservation of vapors at lowest cost.**

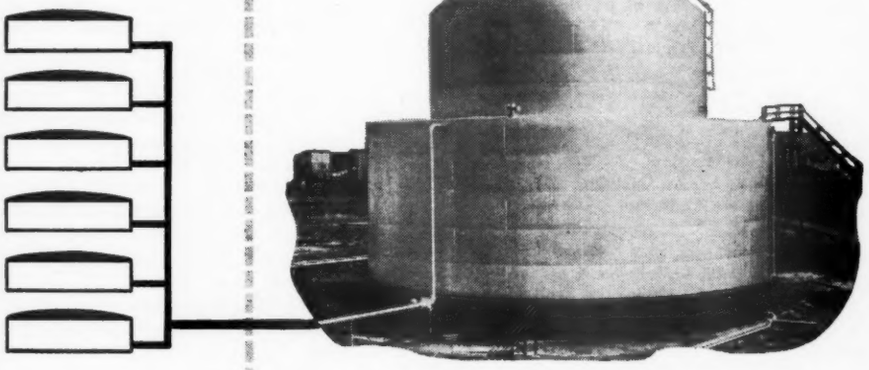


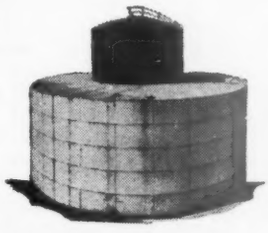
42'6" x 40' Liquid Storage Tank 22' x 17'9" Dialift. Housing — 6500 cu. ft. capacity Inter connected to a 25' x 40' Cone Roof Tank



50' x 48' Liquid Storage Tank 30' x 15'9" Dialift. Housing — 12,500 cu. ft. capacity

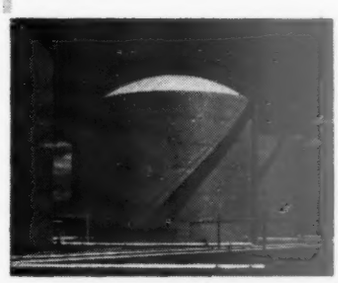
**The DIALIFT consists of a tubular membrane attached gas-tight to the inside periphery of a cylindrical housing. In operation the DIALIFT functions as the lung of the storage tank. The membrane lifts under a slight pressure when additional vapor storage space is needed, and lowers when less vapor space is required; self-adjusting to the constantly changing breathing conditions within the tank.**





80' x 30' Liquid Storage Tank 35' x 17'9" Dialift. Housing — 20,000 cu. ft. capacity

**It is easy to convert an existing Cone Roof Tank to an efficient DIALIFT installation. A DIALIFT housing is superimposed on the existing roof, breather holes are installed through the roof plating permitting a free passage for all vapors, no other preparation is necessary.**



60' x 48' Ground Type Dialift. 150,000 cu. ft. capacity

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XUM

# MEETINGS ★

April 6-8—**Petroleum Industry Electrical Association,** annual meeting, Baker and Adolphus Hotels, Dallas, Texas.

April 8-9—**American Petroleum Institute,** Division of Production, Rocky Mountain District, Casper, Wyoming.

April 8-9—**Instrumentation Conference,** second annual, Louisiana Polytechnic Institute, Ruston, Louisiana.

April 8-10—**American Society of Civil Engineers,** committee on pipe lines, Midland, Texas.

April 11-14—**American Oil Chemists Society,** annual meeting, Plaza Hotel, San Antonio, Texas.

April 12-16—**American Association of Petroleum Geologists, Society of Economic Paleontologists and Mineralogists,** and **Society of Exploration Geophysicists,** annual meeting, St. Louis, Missouri.

April 13-15—**Southwestern Gas Measurement Short Course,** University of Oklahoma, Norman, Oklahoma.

April 14-16—**National Petroleum Association,** semi-annual meeting, Cleveland Hotel, Cleveland, Ohio.

April 17—**Fourth John Zink Process Heating Seminar,** John Zink Burner Company, plant, 4401 South Peoria, Tulsa, Oklahoma.

April 20-23—**American Gas Association** Distribution, Motor Vehicles, and Corrosion Conference, Mount Royal Hotel, Montreal, Canada.

April 21-23—**Natural Gasoline Association of America,** annual convention, Baker Hotel, Dallas, Texas.

April 22—**Illinois Oil and Gas Association,** annual meeting, Hotel Emmerson, Mount Vernon, Illinois.

April 26-28—**Southern Gas Association,** annual convention, Houston, Texas.

May 2-4—**Independent Petroleum Association of America,** midyear meeting, Cosmopolitan Hotel, Denver, Colorado.

May 3-4—**Gas Compressors Institute,** University of Kansas and Southwest Kansas Petroleum Industry, Legion Hall, Liberal, Kansas.

May 3-5—**American Petroleum Institute,** Lubrication Committee, Skytop Lodge, Skytop, Pennsylvania.

May 3-5—**American Geophysical Union,** annual meeting, National Academy of Science, Washington, D. C.

May 6-7—**American Petroleum Institute,** Division of Production, Pacific Coast district, Statler Hotel, Los Angeles, California.

May 3-7—**American Petroleum Institute,** Safety and Fire Protection Committees, midyear meeting, Chase-Park Plaza, St. Louis.

May 9-12—**Liquefied Petroleum Gas Association,** annual convention, Conrad Hilton Hotel, Chicago, Illinois.

May 10-12—**American Petroleum Institute,** Division of Transportation, Products Pipe Line Conference, Warwick Hotel, Philadelphia, Pennsylvania.

May 10-13—**American Petroleum Institute,** Division of Refining, midyear meeting, Rice Hotel, Houston, Texas.

May 14-15—**Interstate Oil Compact Commission,** General Oglethorpe Hotel, Savannah, Georgia.

May 16-19—**American Institute of Chemical Engineers,** Conrad Hilton Hotel, Chicago, Illinois.

May 20-21—**Kentucky Oil and Gas Association,** annual, Lafayette Hotel, Lexington, Kentucky.

May 24-26—**American Gas Association** Production and Chemical Conference, Willim Penn, Pittsburgh, Pennsylvania.

May 27-28—**Natural Gas and Petroleum Association of Canada,** Prince Edward Hotel, Windsor, Ontario, Canada.

May 31-June 5—**American Petroleum Institute,** Division of Production, midyear committee conference, St. Francis Hotel, San Francisco, California.

June 2-4—**Texas College of Arts and Industries,** Short Course in Gas Technology, Texas A & I, Kingsville, Texas.

June 3-4—**Pennsylvania Grade Crude Oil Association,** 31st annual meeting. Hotel William Penn, Pittsburgh, Pennsylvania.

June 6-11—**Society of Automotive Engineers,** summer meeting, Ambassador and Carlton Hotels, Atlantic City, New Jersey.

June 9-11—**Oil Industry Information Committee,** Edgewater Beach Hotel, Chicago.

June 13-18—**American Society for Testing Materials,** annual meeting and exhibits, Sherman Hotel, Chicago, Illinois.

June 17-19—**American Petroleum Institute,** Division of Production, Eastern District, Greenbrier Hotel, White Sulphur Springs, West Virginia.

June 20-23—**American Institute of Chemical Engineers and Institute of Nuclear Energy,** University of Michigan, Ann Arbor, Michigan.

June 20-24—**Canadian Gas Association,** Banff Springs Hotel, Banff, Alberta, Canada.

June 21-25—**American Institute of Electrical Engineers,** combined summer and Pacific general meeting, Biltmore Hotel, Los Angeles, California.

June 25-26—**Southern Gas Association** transmission management conference, Hotel Adolphus, Dallas, Texas.

June 27-July 1—**Petroleum Equipment Suppliers Association,** Manor Richelieu, Murray Bay, Quebec, Canada.

July 21-24—**Human Relations in Industry Conference** (YMCA), Silver Bay, New Jersey.

July 23—**Southern Gas Association,** communications conference, Rice Hotel, Houston, Texas.

July 24—**Southern Gas Association,** dispatcher conference, Rice Hotel, Houston, Texas.

### NOMADS TO MEET

New York N. Y., Chapter, First Monday of the Month, Biltmore Hotel, New York. Secretary, O. B. Latrobe.

Houston Chapter, Second Monday of the month, Ye Olde College Inn, Houston, Texas. Secretary, Harry E. Estes.

Los Angeles Chapter, Second Wednesday of the Month, Jonathan Club, Los Angeles, Calif. Executive Secretary, Wallace A. Sawdon.

Tulsa Chapter, Third Friday, "After Five" Room, Hotel Tulsa. Secretary, Gilbert Swift.

Dallas-Fort Worth Chapter, Dallas, Texas. First or Second Monday of the Month. Secretary, Glen Tableman.

Aug. 17-19—**Society of Automotive Engineers,** international West Coast meeting, Georgia Hotel, Vancouver, B. C., Canada.

Aug. 20-21—**Southern Gas Association,** natural gas processing and pipe line operations conference, Herring Hotel, Amarillo, Texas.

Sept. 6-11—**American Chemical Society,** national meeting, Conrad Hilton Hotel, Chicago, Illinois.

Sept. 7-8—**Association of Desk and Derrick Clubs of North America,** annual convention, Banff Hotel, Calgary, Canada.

Sept. 8-10—**Oil Industry Information Committee,** Chicago, Illinois.

Sept. 9-11—**Interstate Oil Compact Commission,** Omaha, Nebraska.

Sept. 12-16—**American Institute of Chemical Engineers,** Colorado Hotel, Glenwood Springs, Colorado.

Sept. 13-24—**Instrument Society of America,** International Instrument Congress and Exposition and National Instrument Conference and Exhibit, Philadelphia, Pennsylvania.

Sept. 15-17—**National Petroleum Association,** annual meeting, Traymore Hotel, Atlantic City, New Jersey.

Sept. 16-17—**Mid-Continent Oil and Gas Association,** Louisiana-Arkansas Division, annual meeting, Roosevelt Hotel, New Orleans, Louisiana.

Sept. 27-29—**American Institute of Electrical Engineers,** electrical conference for petroleum industry, Mayo Hotel, Tulsa, Oklahoma.

October 4-6—**Petroleum Electric Power Association,** annual, Jung Hotel, New Orleans, Louisiana.

Oct. 4-6—**Texas Mid-Continent Oil and Gas Association,** annual meeting, San Antonio, Texas.

Oct. 7-8—**California Natural Gasoline Association,** annual Fall meeting, Ambassador Hotel, Los Angeles, California.

Oct. 10-11—**American Association of Oil Well Drilling Contractors,** annual, Biltmore Hotel, Los Angeles, California.

Oct. 11-14—**American Gas Association,** Atlantic City, New Jersey, hotel to be named.

Oct. 14-17—**Permian Basin Oil Show,** Odessa, Texas.

Oct. 16—**Southern Gas Association,** transmission management conference, Rice Hotel, Houston, Texas.

Oct. 25-26—**Independent Petroleum Association of America,** annual meeting, Mayo Hotel, Tulsa, Oklahoma.

Oct. 25-29—**American Institute of Electrical Engineers** (tentative date), Fall general meeting, Chicago, Illinois.

Oct. 26-27—**Society of Automotive Engineers,** national diesel engine meeting, Statler Hotel, Cleveland, Ohio.

Nov. 1-5—**American Society for Metals,** national, Palmer House, Chicago, Illinois.

Nov. 8-11—**American Petroleum Institute,** annual meeting, Conrad Hilton Hotel and Palmer House, Chicago, Illinois.

Nov. 28-Dec. 3—**American Society of Mechanical Engineers,** Statler Hotel, New York, New York.

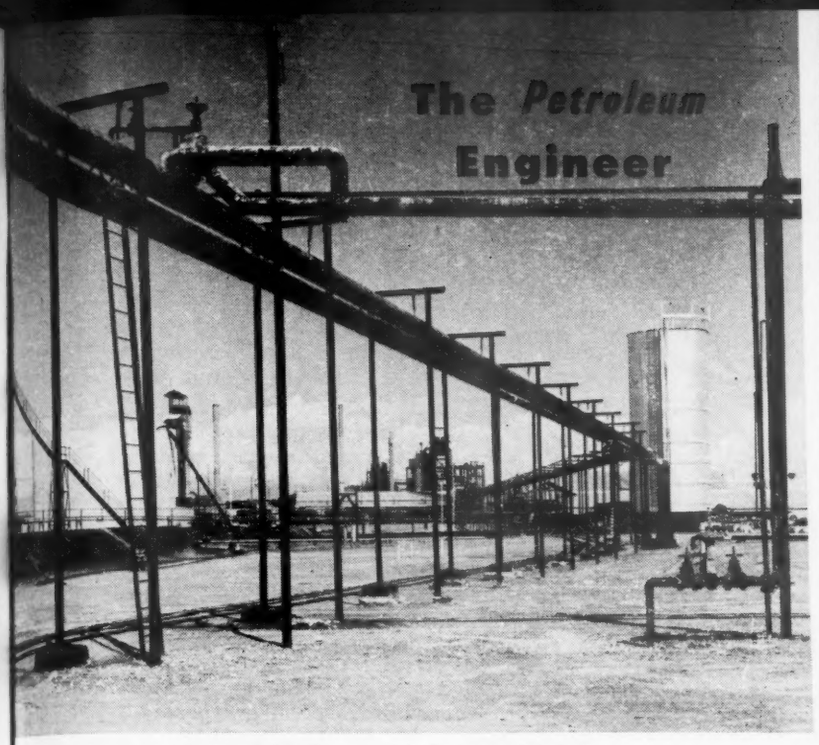
Dec. 12-15—**American Institute of Chemical Engineers,** annual meeting, Statler Hotel, New York, New York.

Dec. 8-10—**Oil Industry Information Committee,** Waldorf-Astoria Hotel, New York.

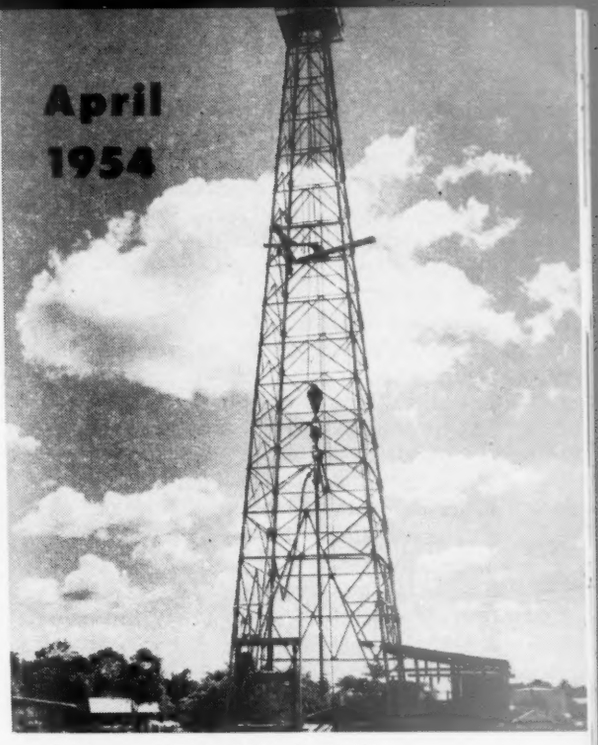
### 1955

May 14-22, 1955—**Deutsche Gesellschaft fur Chemisches Apparatewesen,** chemical plant and apparatus exhibition and congress, Frankfurt am Main, Germany.

June 1-9, 1955—**Fourth World Petroleum Congress,** Rome, Italy.




Refinery of the Tropical Oil Company in Barrancabermeja.




Producing well in the El Centro field.

P 123

# Colombia Is an Active Oil Country

*A total of $76,500,000 will be spent by various operators in Colombia for oil goods and services this year*

E. OSPINA-RACINES

COLOMBIA will represent for the oil industry in 1954 a $76,500,000 dollar market for oil goods and services. The overall budgets of investment on the part of the various operators may be broken down thus: International Petroleum Company (Colombita) Ltd. (Intercol), $12,000,000; Texas Petroleum Company, $20,000,000; Empresa Colombiana de Petroleos, $34,500,000; Shell and others, $10,000,000. These sums will be invested in wildcat drilling, products line pipe and crude pipe line construction and the completion of the Barranca 35,000 bbl per day modern refinery being built by Foster Wheeler Corporation for the account of Empresa, the official oil enterprise. The refinery is now 70 per cent built to be completed by June, 1954.

Another index of the importance of Colombia as a market for oil field equipment and materials is the annual sale of dollars by the oil industry to the Banco de la Republica, the central bank of issue. In 1953 the oil industry sold to the Banco $32,300,000, which compares with $27,600,000 in 1952. These sums are converted into local currency for payment of wages, investments, in both tangible and intangible property in Colombia, and the payment of taxes. The purchase of materials and oil field equipment in the United States is in

EXCLUSIVE

**TABLE 1. Oil operations in Colombia in 1953—by operators and properties.**

| Operator | Property | Miles inland | Royalty payment (per cent) | November B/D & API | Wells producing Nov. 30 |
|---|---|---|---|---|---|
| 1. Empresa Colombiana de Petroleos (Government) | De Mares | 335 | ** 7.5 | 33,960 24.3° | 1080 |
| 2. Colombian Petroleum (Socony-Texas) | Barco | 261 | 10 | 25,642 32° & 45° | 214 |
| 3. Shell Group | Yondo | 324 | 6 | 39,912 21° | 314 |
| 4. Shell Group | Dificil | 135 | 9 | 1070 43° | 11 |
| 5. Shell Group | Cantagallo | 298 | 7 | 1895 21° | 8 |
| 6. Texas petroleum | Teran-Guaguaqui | 400 | 1 | 4467 26° | 10 |
| 7. Texas Petroleum | Tetuan | 550 | *3 | 683 26° | 4 |
| 8. International Petroleum (S.O.N.J.) | Totumal | 220 | 10 | 7 26° | 3 |
| 9. International Petroleum (Intercol) | Aguachica | 205 | 10 | 559 37° | 3 |
| | | | | 108,195 | 1647 |

Note: *royalty beyond 900 k. (558 mi.) 3 per cent if not refined. Tetuan oil output is refined and pays no royalty.
**De Mares pays royalty to the Departmental and Municipal Governments.

direct proportion to the sale of these sums to the Banco. The more activity in Colombia the higher the dollars sale and the greater the purchases of oil field equipment in the United States.

Colombia's oil output during 1953 showed a 2 per cent increase over 1952 and amounted to 39,430,463 bbl of crude and 875,701 bbl of condensate. This equals to 110,428 bbl per day. Table 1 shows the breakdown of Colombia's oil production by operators and properties, the November data amounting to 108,195 bbl per day for crude and with 2444 bbl per day of condensate totals 110,639 bbl per day. From inspection of the data of Table 1 it is noted that oil fields in Colombia are at great inland distances from tidewater ranging from 135 to 550 miles inland. This means pipe lines to carry the oil to seaboard.

For 1954 the various oil operators have substantial exploration and development programs, which may be summarized as follows: The Government oil enterprise, Empresa Colombiana de Petroleos operates the DeMares property and produces some 34,000 bbl per day. Geophysical work by SSCD is now in progress in the northern part of the property as prelude to wildcat drilling. As may be noted from Table 2 the Empresa spudded in 46 and completed 46 wells in De Mares in 1953, having drilled a total of 131,977 ft during the year. The Empresa will complete a 60-mile 8-in. products pipe line running from Barranca refinery to Cantimplora and with this final spread built the Capital, Bogota, will be connected by pipe line to the refinery. Williams Brothers Overseas Corporation built two spreads of the project, the 91 miles from Cantimplora to Pt. Salgar and the 88 miles to Bogota. The latter project of only 87 miles starts at 600 ft above sea level and goes to 8600 ft where Bogota is located. These pipe lines are now operating.

The Empresa will have the 35,000 bbl per day modern refinery completed by June 1954 and will supply a full range of oil products. The plant will have catalytic cracking and will process De Mares 24.31 API crude. The Empresa has further plans to wildcat in De Mares and during 1953 placed in operation a National 130 deep test rig, now drilling around 6000 ft having already encountered very promising pay sections. The well is now some 2000 ft in the Cretaceous, and is situated in the Infantas structure. During the latter part of the year two board members J. J. Turbay and C. Gutierrez and the manager, F. Puyana, visited Mexico, Houston, New York, and Coral Gables in connection with the financing of the wildcat program in other areas of De Mares and for the building of a new 25,000 bbl a day refinery on the coast.

**TABLE 2. Summary of oil drilling and production in Colombia in 1953.**

| Operator | Intercol | Shell | Texas | Empresa | Colpet | Richmond | Socony | Colombia Total |
|---|---|---|---|---|---|---|---|---|
| Wells | | | | | | | | |
| Spudded in | 7 | 38 | 23 | 46 | 29 | 1 | 0 | 144 |
| Completed | 7 | 47 | 23 | 46 | 28 | 0 | 0 | 151 |
| Footage | | | | | | | | |
| Exploration | 35,627 | 32,373 | 49,250 | 5,035 | pending | 6758 | | 129,043′ |
| Development | 40,007 | 172,726 | 134,071 | 126,942 | pending | 0 | | 473,746′ |
| Total | 75,634 | 205,099 | 183,321 | 131,977 | 165,645′ | 6758 | | 768,434′ |
| Oil production | | | | | | | | |
| 1953 B/D | 151 | 43,327 | 4638 | 34,348 | 25,565 | 0 | 0 | 108,029B/D |
| Condensate | | | | 2,399 | | | | 110,428B/D |
| 1952—Year | 0 | 38,921 | 3716 | 34,953 | 27,819 | 0 | 0 | 105,409 |
| Condensate | | | | 2,338 | | | | 107,747 |

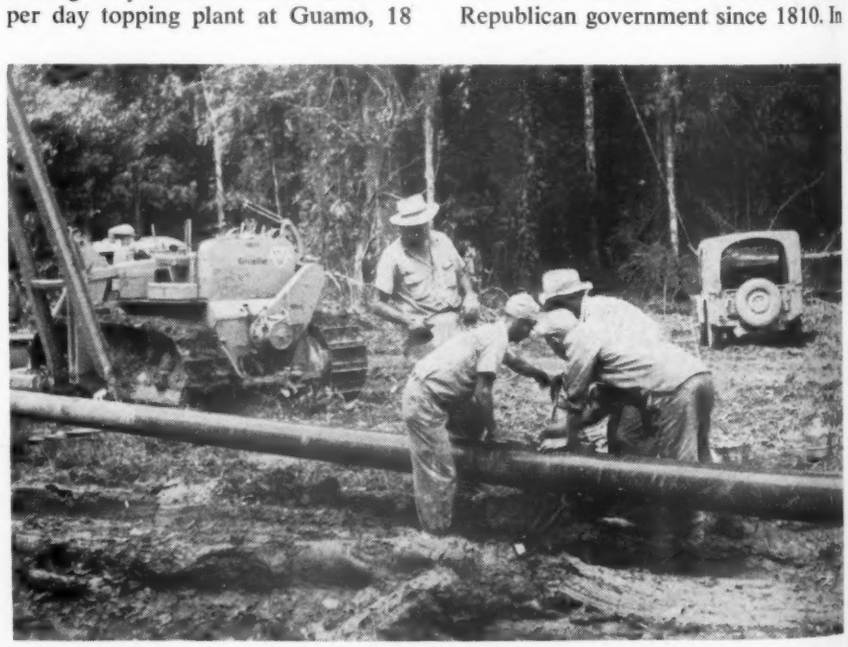
**Summary of oil operations in Colombia 1953.**

| Year | Oil output | Barrels per day | Runs to stills, year | Barrels per day | Crude oil exports | | Average price per bbl |
|---|---|---|---|---|---|---|---|
| | | | | | Volume | Value—dollars | |
| 1953 | 39,430,463 | 108,029 | 11,780,806 | 32,276 | 32,068,989 | $76,294,593 | $2.379 |
| 1952 | 39,682,735 | 105,409 | 11,489,137 | 31,391 | 32,027,087 | $73,347,592 | $2.296 |
| 1951 | 38,398,097 | 105,200 | 9,907,311 | 27,143 | 32,236,969 | $72,880,093 | $2.261 |

Colpet footage subject to revision. (From Dr. Eduardo Ospina-Racines).

Texas Petroleum Company has two producing properties. In the fee property Teran-Guaguaqui the Velasquez field has been object of an intense development drilling program. The first and the discovery well in this property was spudded in December, 1945 and after 8 years 50 wells have been completed. The field is now producing up to 4500 bbl per day of 26 API oil and has a potential of some 8000 to 10,000 bbl per day. Bids are being studied for the construction of a 119 mile 12-in. crude pipe line to connect Velasquez field with the Andian common carrier at Galan, near Barranca where Shell also delivers its crude to Andian.

Texas has a smaller producing property at Tetuan some 550 miles upriver. During the year Texas built a 1000 bbl per day topping plant at Guamo, 18 miles from the Ortega field and the crude is being topped since August last, during December it averaged some 900 bbl per day. Products are motor fuel, 7600 gal per day; diesel fuel 3400 gal per day; fuel oil 780 gal per day. Just near this property Texas will shortly spud in a wildcat in a 14,200 hectare leasehold whose subsoil oil rights were delared private property in a decision of the Supreme Court in 1942. This is one of the private oil properties that have been recognized by the Government or the Courts since 1936. Unlike in other countries, Venezuela, for instance, where all the oil belongs to the state and concessions must be obtained for drilling, in Colombia both state and private oil exist. In the latter case the alleged owner must show evidence as prescribed by law that title to the property was acquired prior to 1873 from either the Crown or the Republican government since 1810. In



**Harold H. Brady, general field superintendent, supervising construction for William Brothers Overseas Corporation, the contractors who built the 8-in. products pipe line to supply Bogota 8600 ft above sea level directly from Barranca refinery.**

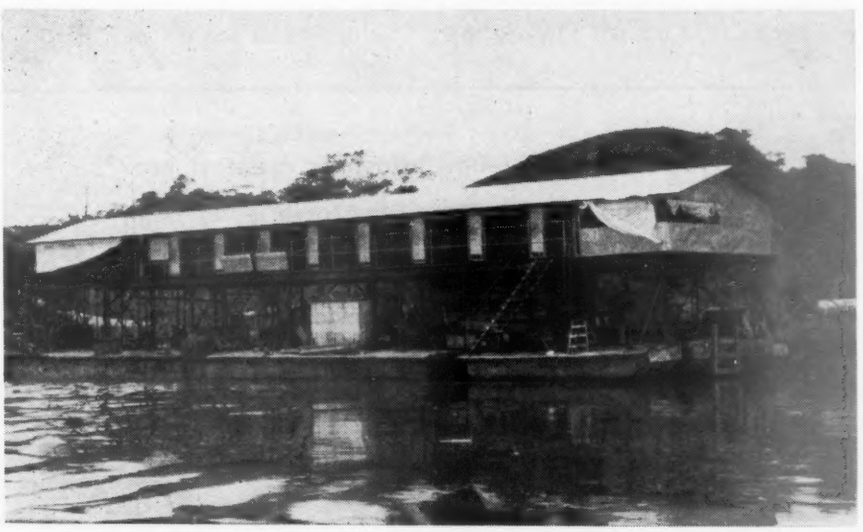
such event the oil belongs to the owner of the surface property.

The outstanding event of the year from an explanatory standpoint was the strike made by Intercol in the Mid-Magdalena valley in its Totumal and Aguachica blocks only 200 miles from tidewater and through which the Andian comomn carrier passes. The Totumal discovery took place in 1951 and was developed during 1952 and 1953 a total of 6 wells have been drilled. The Aguachica discovery took place in 1953 and three pdroducers have been completed and two wells suspended. One of these Crisol blew out and took fire early in December 1953 causing a complete loss of the rig and fortunately no personal injuries. Paul Adair of the Kinley fire fighting staff flew to Colombia put out the fire within six days, on December 9.

Intercol announced during the latter part of the year that it had plans to build a modern 25,000 bbl per day refinery on the coast, at Cartagena where the Andian common carrier has its export terminal. This may be a $30,000,000 dollar investment not listed previously in the $76,500,000 program for Colombia in 1954. The Government seconded Intercol's program and established the following terms: (1) that the project be started so as to be completed by the end of 1957; (2) that the throughput not be less than 25,000 bbl per day; (3) that Colombia's domestic requirements be met prior to exporting any oil products; (4) that sale of products be free at the plant; (5) that crude from Colombian oilfields be given preference if technically adequate; (6) that approval be obtained once the site is selected, from the Ministry of War. Preliminary work has already begun on this project.

As may be seen from the data of Table 2 the Shell group of companies produces the bulk of the oil output. Three properties yield the oil as indicated in Table 1. At present Shell has two rigs drilling, one in Cantagallo and one in San Pablo. In the latter block drilling is being done directionally to search for the oil deposit underneath the Magdalena River and is now at around 8000 ft. Shell completed 47 wells in 1953 of these 39 producers in the Yondo block, Casabe field which is now completely drilled up, having drilled a total of 394 wells in this field of which 314 are on production. Two wildcats were completed Manati 1 to 11,437 ft and the Magangue 2 well at 11,538 ft both in the same general area, just south of Barranquilla some 40 and 100 miles south of this town, Bolivar department, both dry and abandoned. Shell has plans to drill in the Middle-Magdalena valley area in

**Richard P. George, drilling superintendent, Max E. Crawford, assistant general manager, Domingo Vargas, M. D.; F. de Cimgeda, industrial relations supervisor, at the Crisol blowout. All are from Intercol, International Petroleum (Colombia) Ltd.**



**House boat of William Brothers Overseas Corporation on Magdalena River to service staff building the 8-in. products pipe line, 19,000 bbl per day to supply Colombia's capital, Bogota, with oil products.**

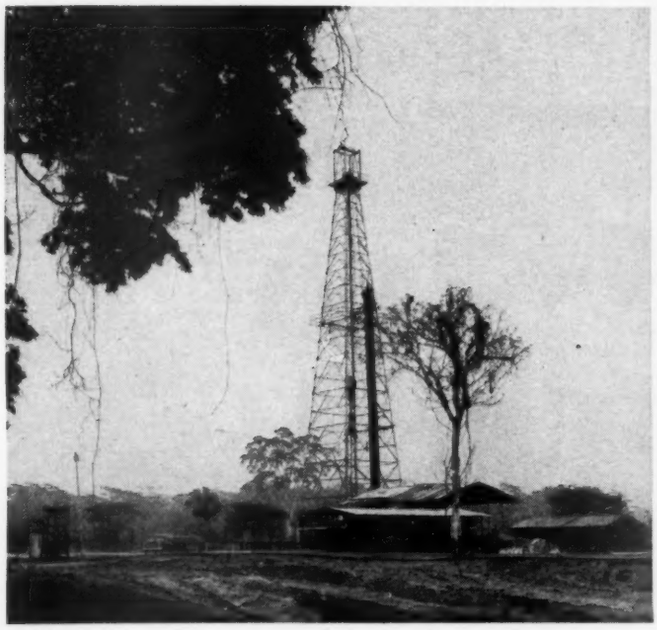
**The Author**

E. Ospina-Racines issues weekly the *Colombian Oil-News Digest; Colombian Wildcat News; Oil Drilling and Production in Venezuela and Peru;* and has published three books on oil, the most notable one of which has had sales in 34 different oil countries of the world, entitled, "The Economics of United States and World Oil." E. Ospina-Racines was elected president of the Colombian Petroleum Institute for 1954.

He studied at the Colorado School of Mines, College of the City of New York, Columbia University, University of Paris, worked a year in a refinery in the United States and when he returned to Bogota after an absence of a number of years he decided to study law. In 1935-1939 he was vice consul of Colombia in New York in charge of petroleum matters and in the latter year he returned and remained with the Ministry of Mines and Petroleum for a short time and then launched himself in the business of publishing oil information.



XUM



**Totumal No. 2 in the International Petroleum Company's exploration field near Gamarra, Colombia.**

**Luis E. James operating extraction equipment in the refinery laboratory at Barrancabermeja.**

1954. Besides the drilling program Shell has embarked on an oil products marketing venture with some 20 super stations to be located and are now building throughout the country. Five of these will be in Bogota, the first one of which will be opened up in November of this year. There is only one marketer of oil products on a large scale, namely Esso Colombiana S.A.

Colombia consumes currently 27,000 bbl per day in oil products. Of Colombia's total crude oil output of 110,000 bbl per day, 81 per cent is exported the 19 per cent retained or 20,900 bbl per day must be supplemented by imports from Aruba at the rate of some 6100 bbl per day. Motor fuel is being consumed at the rate of 11,000 bbl per day and since the topping plant capacity is insufficient, having topped an average of 32,300 bbl per day in 1953 but not obtained the required products from these operations, imports of oil products are necessary. Motor fuel from Aruba is sold in Bogota, being transported 600 miles inland, and to 8600 ft above sea level. A gallon at the service stations in Bogota for 72 octane fuel sells at 24 cents. This is a relatively low price compared to the prices of other capitals in South America.

LPG is being marketed in three cities in Colombia. Current monthly output from the gas plant at De Mares is 300,000 gal or some 7500 bbl per month. The market is big but the supply is limited which will be corrected as soon as the modern refinery is completed in mid-1954 at Barracca. Colpet, operator of the Barco, Tables 1 and 2, just completed and placed on stream a modern 60,000,000 cu ft per day gas plant and a topping plant 2000 bbl per day which was designed and built by the Fluor Corporation. The plant represents $7,000,000 dollars. The products will be used to upgrade the motor fuel and to blend with the crude oil exported.

The Standard Oil Company of California through Richmond Petroleum Company is active.

Richmond is now drilling on the Pacific coast not only in Colombia but also in Peru. The wildcat in Colombia is in the Buchado block, only 36 miles from Pacific tidewater and is now down to 7005 ft whereas its Peruvian one is below 5600 ft. If the Richmond makes a strike it will prove a vast oil zone on the Pacific which is also Colombia's foremost gold and platinum producing area. Rainfall in this Choco area exceeds 450 in. per year, one of the world's heaviest rainfall zones. The test represents a $2,000,000 dollar program.

Summarizing, Colombia is an active oil country with a promising oil development future not only as a world oil supplier but also for the benefit of the country in meeting future oil domestic demand and offering innumerable opportunities for Colombians to train in the oil industry. Under the new regime of Lieutenant General Rojas established June 13 the country has experienced a remarkable transformation. The Government recently appointed a three-member commission representing industry and the Government to study how Colombia's tax laws affect the economy of the oil industry and what measures would be recommended to place Colombia's prospective oil land on a definite competitive position with such land elsewhere abroad. ★ ★ ★


***Was 1953 the petroleum industry's greatest year?***

***What will the industry spend for facilities in 1954?***

***What do individual oil companies think of the future?***

Read the answers to these and many other questions in the Eighth Annual survey by Ernestine Adams of

**62 OIL COMPANY FINANCIAL REPORTS**

Coming in the May 1954 issue of

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### Tidelands Reserves

The petroleum potential of the tidelands has been recognized and a subject of ever-growing interest and activity since the first seismic explorations of the tidelands in the early 1930's.

According to the 1953 report of the National Petroleum Council, it is estimated that 170,000 to 200,000 bbl daily of crude oil and 600,000,000 to 800,000,000 cu ft daily of natural gas might be developed with average success from these offshore submerged lands. Some of Texas' leading geologists estimate oil, gas, and sulfur reserves off the shores of Texas alone to be worth in excess of $80 billion.

★ ★ ★

### Oil Search in Egypt

*The Egyptian Government and the Anglo-Egyptian Fields, Ltd., and Socony Vacuum Company are to sign soon an agreement, reached verbally, to resume search for new oilfields in the Sinai Desert and along the western shore of the Red Sea. Dr. Mahmud Abu Zeid, Director-General of the Fuel Department, announced early in February that a new oil well had been located in the Wadi Feran concession in Sinai.*—V.S.S.

★ ★ ★

### Gas Drilling

AGA, at New Orleans meet, had report on gas drilling operations in New Mexico. San Juan Basin operators, faced with formation damage if drilled with mud and lost time and excessive gas loss if drilled with standard tools, now set casing on top of Mesa Verde, drill in and shoot using gas as a circulating medium. Time saved amounts to as much as six weeks per well and completion costs have been decreased by about $20,000 per well.

★ ★ ★

### Secondary Recovery

Detailed discussion of results from flame floods continue to invite operators on this latest development in secondary recovery. Now past its fifth year of study by Sinclair scientists and engineers, a report given at a New York meeting of AIME said that estimates of 50 per cent immobile oil by conventional recovery methods have been reduced. Process "practically stripped (the formation) of its original oil content." In Sinclair method a small portion of reservoir oil is burned in place, creating a heat wave to move oil.

### World's Greatest?

Almost positive proof that Aramco's newest Saudi Arabian discovery is the largest single reserve ever found exists. It becomes more apparent daily that the Ghawar field will eventually comprise an area 130 miles long by 20 miles wide. While an area in the center of the field some 30 miles long has not been drilled, all available evidence points to its being productive.

Productive sand thickness has been ascertained in excess of 107 ft. Reserves of the field have not been calculated — certainly they will exceed 30 billion bbl and the probability of their approaching 60 billion is excellent.

Market proration and operating restraint has held Saudi Arabia production to date under 1,000,000 bbl per day.

★ ★ ★

### Montana Strike

Completion of a Moulton sands oil well which produced at the rate of 3984 bbl of 40 API gravity crude oil a day on swab test has been announced. Located nine miles west of Sweetgrass, Montana, the well, Ponder Pattie Stewart-State No. 2 was drilled to 2652 to open up 42 ft of Moulton sands. Producing equipment is being installed.

★ ★ ★

### Bottom-hole Heaters

*Successful use of electric heating elements in some wells in the Cut Bank field of Northern Montana has been reported. Heaters are run on bottom of tubing string and operated intermittently. Results may stem from melting paraffin in well bore, lowering viscosity of crude in vicinity of bore, and or lowering surface tension of crude and water. Method is promising for certain type stripper wells.*

★ ★ ★

### British Oil Report

Following tests of Well No. 2 at Plungar near Nottingham, England, by D'Arcy Exploration Company, the presence of a commercial oil deposit in lime at 3029 ft has been established. The company is rigging up on No. 3 with additional locations staked. The discovery well in this field was reported as a pumper with an initial capacity of 30 to 35 bbl per day. Meanwhile, a deeper test for gas by the same company has been started in the Cousland area of Scotland. (U.S.S. report.)

### Open Denver Office

Signal Drilling Company has announced opening of its Rocky Mountain Division office in the Patterson Building in Denver. The company operates both rotary and cable tool rigs throughout the Rocky Mountain area and in Canada. F. M. Stevenson, president, will be in charge of the Denver office.

★ ★ ★

### Pembina Expands

With 18 drilling rigs in operation in the Pembina area of Alberta, new discoveries are coming almost daily. Socony-Vacuum reported a new discovery in the Missisippian formation at the south end of the field. Canadian Delhi Oil Limited et al found Cardium sand oil in the Minnehik area four and a half miles southeast of the area's previous most southerly Cardium sand production. Stanolind found oil in the Mississippian formation a few miles east of Pembina, and a fourth discovery was made by New Superior Oils of Canada et al at a point approximately 10 miles southwest of Pembina.

Pembina is the most promising development in the Canadian oil industry in some time. Some industry sources predict it will be larger than the Leduc and Redwater fields, now the country's largest.

★ ★ ★

### Yates Water Injection

Howard-Glasscock production between these two Texas counties is reported in the upgrade after repressuring of the Yates sand began in early 1952. Operation after 16 months operation is showing excellent results with produced oil-injected water ratio of 1 to 2.75.

★ ★ ★

### Assam, India

The Assam Oil Company Ltd. is conducting a geophysical exploration program in the alluvial area of the Brahmaputra Valley. Helicopters are helping to speed up the seismic work during the dry season, and an aircraft is carrying out an aero-magnetic survey over 10,000 sq miles of Upper Assam. Simultaneously, a gravity party is at work elsewhere in this vast region.

The company is drilling Nahorkatya No. 2 well in the Lakhimpur district of Upper Assam as the first step in the development of deep oil prospects found by their discovery well late in 1953. The new well, spudded in January, 1954, is slated to go to 10,000 ft. V.S.S.

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## What is a Permanent-Type Well Completion?

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A Permanent-Type Well Completion is generally considered to be an installation providing for completion, production, repair or recompletion in other zones without requiring a drilling or work-over rig.

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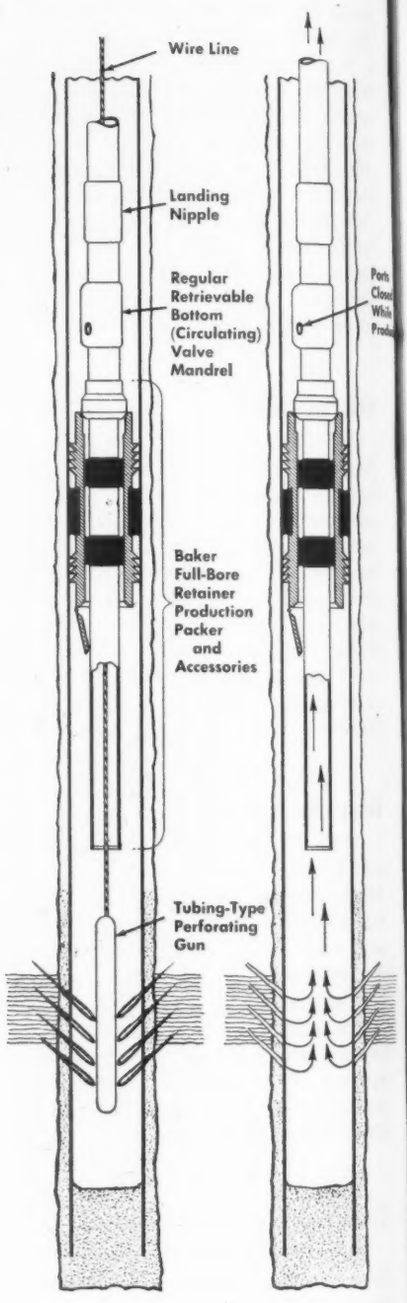
If the completion is successful, the tubing need never again be moved until all zones of the selected interval have been exhausted.

### *Advantages Claimed for Permanent-Type Well Completions*

1. **SAVES AT LEAST ONE TO TWO DAYS RIG TIME during the original completion.**
2. **ELIMINATES COST OF SEPARATE TESTING AND SQUEEZE TOOLS.**
3. **REDUCES WORK-OVER COST AS MUCH AS 75%, by eliminating work-over rig, cost of mud, time and equipment to kill well. Reduces loss of production through saving in work-over time.**
4. **PERMITS THE ECONOMICAL TESTING OF THIN OR QUESTIONABLE SECTIONS.**
5. **PERMITS USE OF WATER INSTEAD OF MUD while perforating completing, or re-completing. This practice reduces formation contamination and may result in an increase in the productivity of the zone.**
6. **PERMITS A MORE ACCURATE ANALYSIS OF RESERVOIR POTENTIAL.**
7. **KEEPS WELL UNDER CONTROL AT ALL TIMES.**




***Where PACKERS are required . . . specify a . . .***

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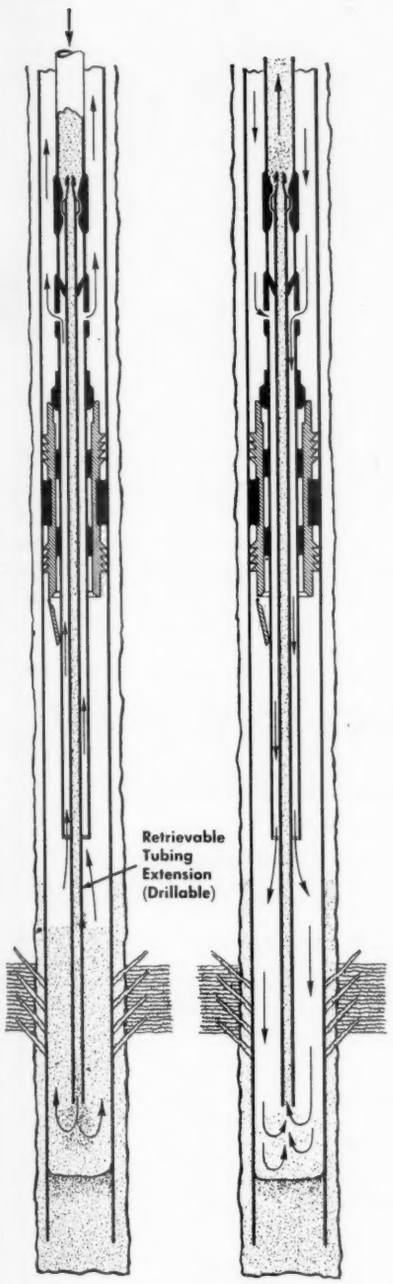
# R.. for Permanent-Type Well Completions

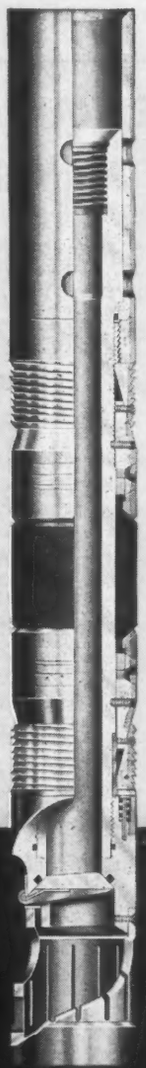



SQUEEZING REVERSING

## BAKER PACKERS ADD PERMANENCE TO PERMANENT-TYPE WELL COMPLETIONS

When you select a Packer for a Permanent-Type Well Completion, remember this fact: of all the tools used in permanent-type well completions, only the *Packer* is required to be *permanent.* Guns, Extensions, Plugs, Gas-Lift and Circulating Valves can be removed or replaced on wire line . . : but the Packer, like the casing, is required to perform for the life of the selected producing intervals.

Baker Packer Completions are Permanent Completions from the standpoint of packer performance. Check these important advantages of the Baker Packer in Permanent-Type Well Completions:



### *Advantages of Baker Retainer Production Packer in Permanent-Type Well Completions:*

1. **PERMANENT, RELIABLE PACK-OFF will hold against any pressure differential from above or below that is safe for the casing.**
2. **FREE TUBING STRING . . . neither set-down tubing weight nor tubing tension required to achieve and maintain pack-off. Tubing can be anchored to Packer if desired.**
3. **CAN BE USED AS A SQUEEZE OR A PRODUCTION TOOL.**
4. **MEETS PERMANENT-TYPE WELL COMPLETION DIMENSIONAL REQUIREMENTS.**
5. **CAN BE SET ON WIRE LINE.**
6. **PERMITS EASY REMOVAL OF TUBING STRING.**
7. **READILY DRILLABLE IN CASE OF EMERGENCY OR NEED.**

**BAKER OIL TOOLS, INC.**
HOUSTON • LOS ANGELES • NEW YORK

# BAKER

RETAINER PRODUCTION PACKER
PRODUCT NO. 415-D

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### Canadian Reserves

Increases in Canada's established liquid petroleum reserves continue to out-pace the annual production rate. New discoveries and extensions of known pools accounted for a 300,000,000-bbl boost in 1953.

The country's total underground petroleum potential is now set at 2,044,000,000 bbl in the annual report of the Canadian Petroleum Association. Reserves consist of 1,845,000,000 bbl of crude oil and 198,000,000 bbl of natural gas liquids.

★ ★ ★

### API Group Meets

Following an informative and valuable session of API Southwestern district meeting to discuss tidelands operations and problems, announcement of new district officers was made.

S. C. Oliphant, Tennessee Production Company, Houston, is new Southwest district chairman. He will guide API production division activities in Arkansas, Louisiana, Mississippi, New Mexico, and Texas. Charles Doh, Schlumberger, Inc., New Orleans, is the Secretary-Treasurer and Lew F. Davis, Atlantic Refining, Dallas, chairman district advisory committee.

★ ★ ★

### Offshore Operations

*Formation of American Tidelands, Inc., to provide new offshore drilling facilities for the petroleum-rich tidelands has been announced. Companys' operations will be conducted with unique drilling barge operating in deeper and unprotected water of the Gulf of Mexico with fully portable equipment. Barge will be capable of drilling to a depth of 18,000 ft in waters to a depth of 45 ft and will be able to operate in the heretofore unexplored deeper waters of the Gulf.*

★ ★ ★

### Mid-Continent API

Record breaking attendance in excess of 1000 members and guests featured the Mid-Continent Division of Production spring meeting of the American Petroleum Institute held in Oklahoma City the 17, 18, and 19 of March. Topics of broad interest to producing personnel were offered, including papers on drilling, completion practices, flame-flooding, and fracturing. The meeting also provided for the election of officers to serve for the next year. Fred Neslage, Pampa, Texas, was elected as the new chairman of the Mid-Continent district. C. A. Husted, also of Pampa is secretary treasurer.

### Armour Expands Research

Laboratory facilities of Armour and Company's Chemical Division have been expanded to include a petroleum research section. This addition is the result of increasing use of the company's fatty acids and fat-derived chemicals by the petroleum industry. The new petroleum group will be headed by Dr. L. L. Bott with efforts in the direction of further use of fatty acids and derivatives in oil recovery.

★ ★ ★

### B of M Reports

Revised and reissued, R.I. 5025, "Determination of Porosity by a Bureau of Mines Method" presents a rapid test for porosity determination of oil and gas bearing sands. Made available in response to industry demand, the new issue tabulates the results of more than 4800 porosity determinations for oil sands in fields in 13 states.

Also announced was R.I. 5031, "Analytical Methods of Testing Waters to be Injected into Subsurface Strata." Covering field corrosion tests and chemical analysis of water, methods used are universally applicable.

### West Australia

*Permits for petroleum exploration have been granted to seven new companies and cover 233,000 square miles in both north and southwest Australia. Initial permits to explore areas are for two years, and any extension would be only where operations had proved satisfactory to the Ministry of Mines.*—V.S.S.

★ ★ ★

### Tidelands Drill Permits

More than thirty American concerns have filed applications with the Army's Corps of Engineers for permits to construct oil well drilling structures on the Texas Tidelands since Congress passed the Submerged Lands Act May 22, 1953. About 25 additional applications had been filed before the law was enacted. The first permit issued since the law was passed went to the Texas Company for the construction of an oil well structure for drilling in Louisiana.

Applications for permits are approved by the Corps of Engineers under the Federal law which requires prior permission from the Army before any structure is placed in a navigable water and work may commence.

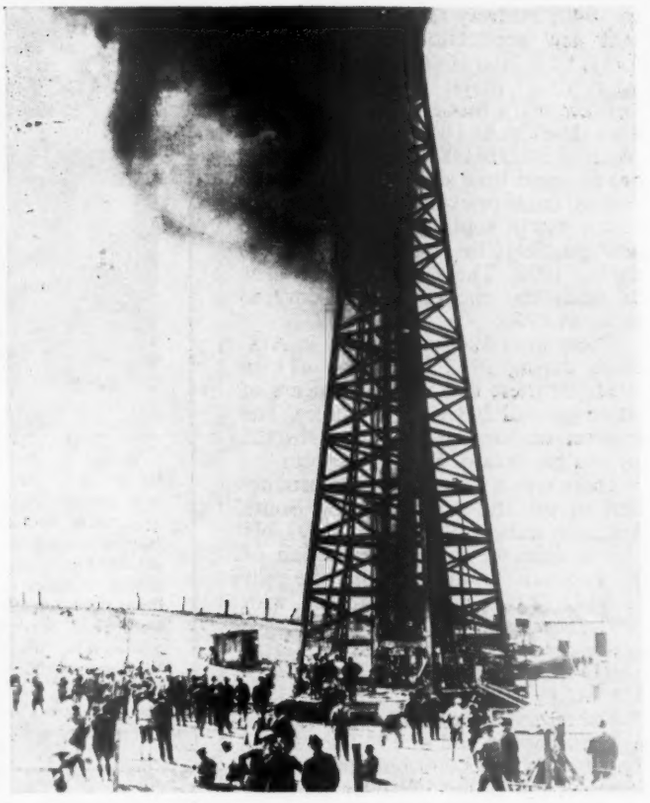
**REDUCE YOUR PRODUCTION COSTS 35-65% BY PERMANENT WELL COMPLETION**

Here is the subject the whole industry is discussing . . . it's featured in your May issue. Read these standout points included in this discussion on Permanent Well Completion.

. . Economics of Operation
. . Basic Objectives
. . Well Preparation
. . Surface Equipment
. . Perforating Equipment and Technique
. . Squeeze Cementing and Plug-Back
. . Well Conditioning and Treating
. . Testing
. . Engineering Advantages
. . Future Challenge

**Read the full story of this remarkable new method of well completion, plus many more engineering-operating articles in your May "Drilling and Producing" Edition.**

**BUSEY-ARMSTRONG NO. 1,** sec. 31, T. 17 S., R. 15 W., Union County. First commercial oil well in Arkansas blew in on January 10, 1921, producing 3000 to 10,000 bbl oil and salt water.



**BOGGS NO. 1,** South El Dorado field, shows early method of bringing in oil wells in Arkansas.

## *Oil and Gas Development*

# Arkansas Found Largest Gas Fields Recently

**W. L. DOBIE**

ARKANSAS has taken a leading part in the conservation of oil and gas among the oil producing states. It has endeavored to eliminate waste and to recover the maximum of oil and gas from the reservoirs. This has resulted in worthwhile dividends, both to the state and to the oil industry. It might be worthwhile to mention that the pressure maintenance project for the Midway field of Lafayette County was the first fresh water pressure maintenance operation early in the life of a field; also the sulfur reclamation plant in operation in the McKamie-Patton field was the first plant in the United States to recover sulfur from natural gas. Sulfur had been removed from natural gas in order that the gas might be used commercially, but now sulfur was utilized.

Oil production is at present confined to the Coastal Plain of South Arkansas in eight counties: Miller, Lafayette, Nevada, Columbia, Union, Ouachita, Calhoun, and Ashley.

Gas production, not associated with oil or condensate, is confined to Northwest Arkansas in six counties: Crawford, Franklin, Johnson, Sebastian, Scott, and Pope.

Gas was discovered at Fort Smith, Sebastian County, in 1888 but not in commercial quantities. The first gas of commercial value was brought in near the town of Mansfield in Sebastian County in 1901. The development of the gas area of Northwest Arkansas was along conservative lines and there was no unnecessary waste and dissipation of the state's gas reserves. The opposite was true of the early development of the oil area.

The first oil was found in Arkansas a little east of Stephens, Ouachita County, in 1919. It was not commercially important. A large gas well with a good showing of oil was brought in west of El Dorado, Union County, in 1920, and in January 1921 the first commercial oil well in Arkansas was brought in a mile west of El Dorado, Union County. The completion of this well started the production and rapid development of oil in Arkansas.

The resultant active drilling campaign led to the discovery of the Irma field in 1921, and East El Dorado, Stephens, and Smackover in 1922. Development of the latter field kept the oil industry in Arkansas busy until the thirties. The oil picture was discouraging and production declined steadily during the early thirties. Interest revived with the bringing in of the Schuler field in 1937, which was followed by Magnolia in 1938, Dorcheat-Macedonia in 1939, McKamie-Patton

EXCLUSIVE



XUM

in 1940, Midway in 1942 and important new production in Stephens in 1941, 1945, and 1946. There have been no fields of major importance in the last few years, though many fields have been developed. The state's production reached 30,000,000 bbl in 1944 and has changed little since. There were 17 new oil fields or extensions to old fields discovered in South Arkansas, and two new gas fields in Northwest Arkansas during 1952. There have been 9 new oil fields and one gas field discovered so far in 1953.

There were 426 wells drilled in Arkansas during 1952 as against 411 in 1951. Of these 218 were producers of oil or gas and 208 were dry holes. The greatest amount of drilling is in the oil and gas area of South Arkansas.

There was a decrease in the production of oil and condensate in South Arkansas during 1952 of 437,497 bbl also a decrease in the production of gas in South Arkansas during the year of 912,972,000 cu ft compared with 1951. There was, however, an increase in the production of dry gas in Northwest Arkansas during 1952 of 2,175,923 MCF, as compared with 1951.

The reserves of oil and condensate in Arkansas at the end of 1952 were estimated at 342,433,000 bbl, an increase of about 8,943,000 bbl over previous year's estimate of 333,490,000 bbl.

Reserves of natural gas in Arkansas at the end of the year were estimated as 952,617 MMCF, a decrease during the year of 114,256 MMCF. This represents a decrease in the reserves of gas in South Arkansas and an increase in northwest Arkansas. Reserves of natural gas in South Arkansas at the end of the year were estimated as 731,389 MMCF, a decrease during 1952 of 146,620 MMCF. The reserves of sweet dry gas in Northwest Arkansas at the end of the year were estimated as 221,228 MMCF, an increase of 32,364 MMCF during 1952.

Accompanying this report is (1) a map showing the gas fields of Northwest Arkansas, (2) a map showing the oil and gas fields of South Arkansas, (3) a structural map of the Magnolia field, Columbia County, (4) a structural map of the Spirit Lake field, Lafayette County, (5) a map showing the effective sand thickness of the Wesson Hogg Sand pool, Ouachita County, (6) a chart showing the pressure production history of the Midway field, Lafayette County, (7) a chart showing the pressure production history of the Wesson Hogg Sand pool, Ouachita County, (8) a chart showing the pressure production history of the Jones Sand pool of the Schuler field, Union County, and (9) a graph showing the production of oil in Arkansas from 1920 to July 1, 1953.

The oil and gas developments are reviewed under two headings (1) South Arkansas and (2) Northwest Arkansas.

## South Arkansas

There were 92 oil and gas condensate fields in South Arkansas on the 15th of August, 1953, most of them producing from more than one horizon. The fields located on faults, folds, and stratigraphic traps produce from rocks of Cretaceous and Jurassic Age. There were 29,440,280 bbl of oil and condensate and 58,179,184 MCF of gas produced in South Arkansas during the year 1952. This was a decrease of 437,487 bbl of oil and condensate and 889,678 MCF of gas from 1951. The cumulative production to January 1, 1953, was 875,117,359 bbl of oil and condensate, and 766,069,012 MCF of gas.

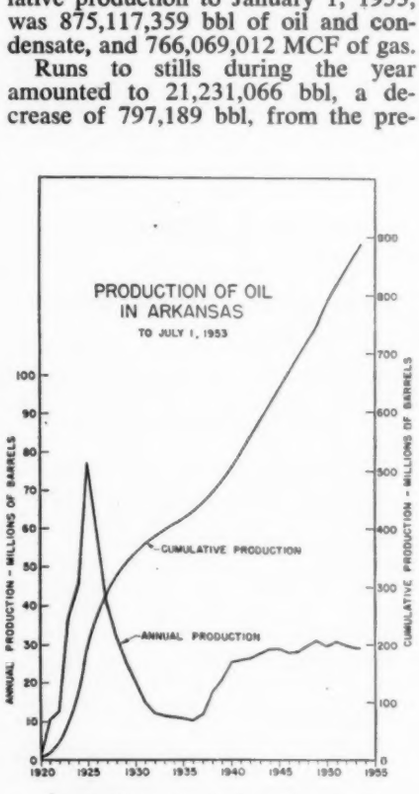
Runs to stills during the year amounted to 21,231,066 bbl, a decrease of 797,189 bbl, from the previous year, and the intake volume of the gasoline plants amounted to 77,128,456 MCF, an increase of 5,912,461 MCF for the year.

The Magnolia field in Columbia County, again led the fields in oil production in 1952, with an output of 4,223,145 bbl. The old Smackover field, uncontrolled and in the stripper stage, again was second in 1952 with 3,813,957 bbl. The Wesson field, Ouachita County, a controlled field, was again third in 1952 with 3,509,982 bbl. The Midway field, Lafayette County, a controlled field, was fourth in 1952 with 2,673,595 bbl, and the Schuler field, Union County, a controlled field, was fifth in 1952 with 1,956,428 bbl.

**The Author**

W. L. Dobie

**Walter L. Dobie is the geologist for Arkansas Oil and Gas Commission in El Dorado, Arkansas. He was graduated from the University of Oregon, later attending the University of Wisconsin. He spent a year at Missouri School of Mines as an instructor. Dobie spent three summers with the Wisconsin Geological Survey, and one year as geologist on the Cuyunga Iron Range, Minnesota. After taking time out for World War I, he has been engaged in geological work concerned with finding and producing oil.**




**Production of oil in Arkansas to July 1, 1953.**

## Pressure Maintenance

The term primary recovery is the term popularly applied to the ordinary methods of recovering oil before the injection of gas or water into the reservoir. The following definitions relating to fluid injections, pressure maintenance and secondary recovery have been approved by the Executive Committee of the American Petroleum Institute on Drilling and Production Practice. Fluid injection is a method of recovering oil, gas and/or related hydrocarbons in which part of the energy effective in moving these hydrocarbons through a reservoir is applied from extraneous sources by injection of liquids or gases into the reservoir. Primary pressure maintenance is an application of fluid injection early in the producing life of a reservoir when there has been little or no loss of natural reservoir energy. Secondary recovery is an application of fluid injection when a reservoir is approaching or has reached economic production limits.

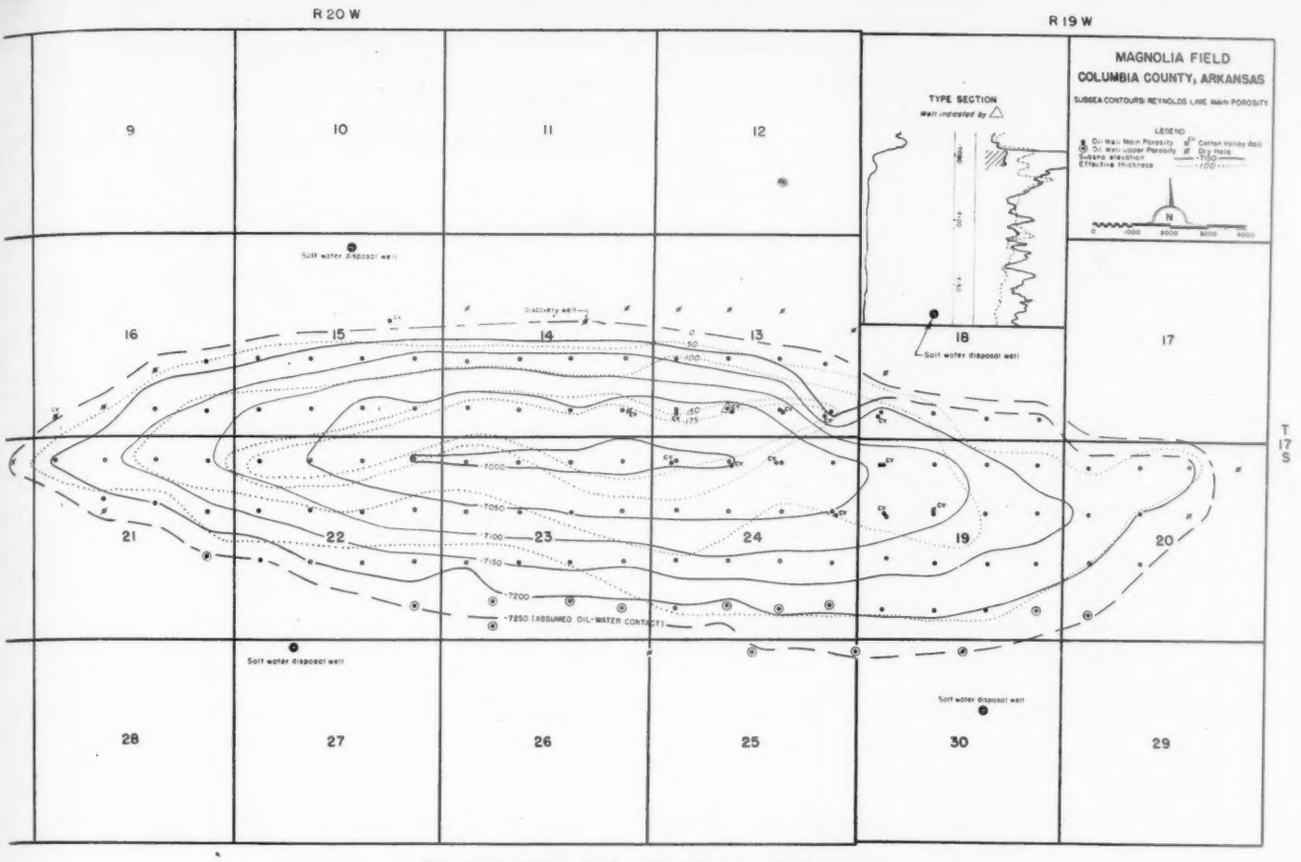
Results of pressure maintenance by injection of gas or water into the reservoirs have been satisfactory for 1952 and are summarized briefly below:

**The Atlanta field,** Columbia County, produces mainly from the Smackover limestone of Jurassic Age about 8200 ft in depth, and is located on a closed anticlinal fold. The limestone reservoir has had a salt water disposal well in operation since 1946. There have been 7,732,931 bbl of water injected into the Smackover reservoir through this one well to January 1, 1953, of which 1,821,096 bbl were injected in 1952. There is a water drive in the reservoir, and while the salt water disposal well will retard slightly the drop in bottom hole pressure, it will have little effect on the recovery of oil from the reservoir. This limestone pool produced 757,311 bbl of oil in 1952, a decline of 24,574 bbl from 1951; 1,388,055 MCF of gas, an increase of 51,000,000 cu ft over 1951; and 2,234,335 bbl of salt water. The cumulative recovery to date is 13,946,953 bbl of oil and 22,387,305 MCF of gas.

There has been a slight increase in bottom hole pressure for the year from an estimated 2433 psi to 2521 psi.

Estimated reserve with 55 per cent recovery is 5,577,000 bbl of oil.

**The Haynesville field,** three-quarters of which lies in Louisiana and one-




**Magnolia field, Columbia County, Arkansas.**

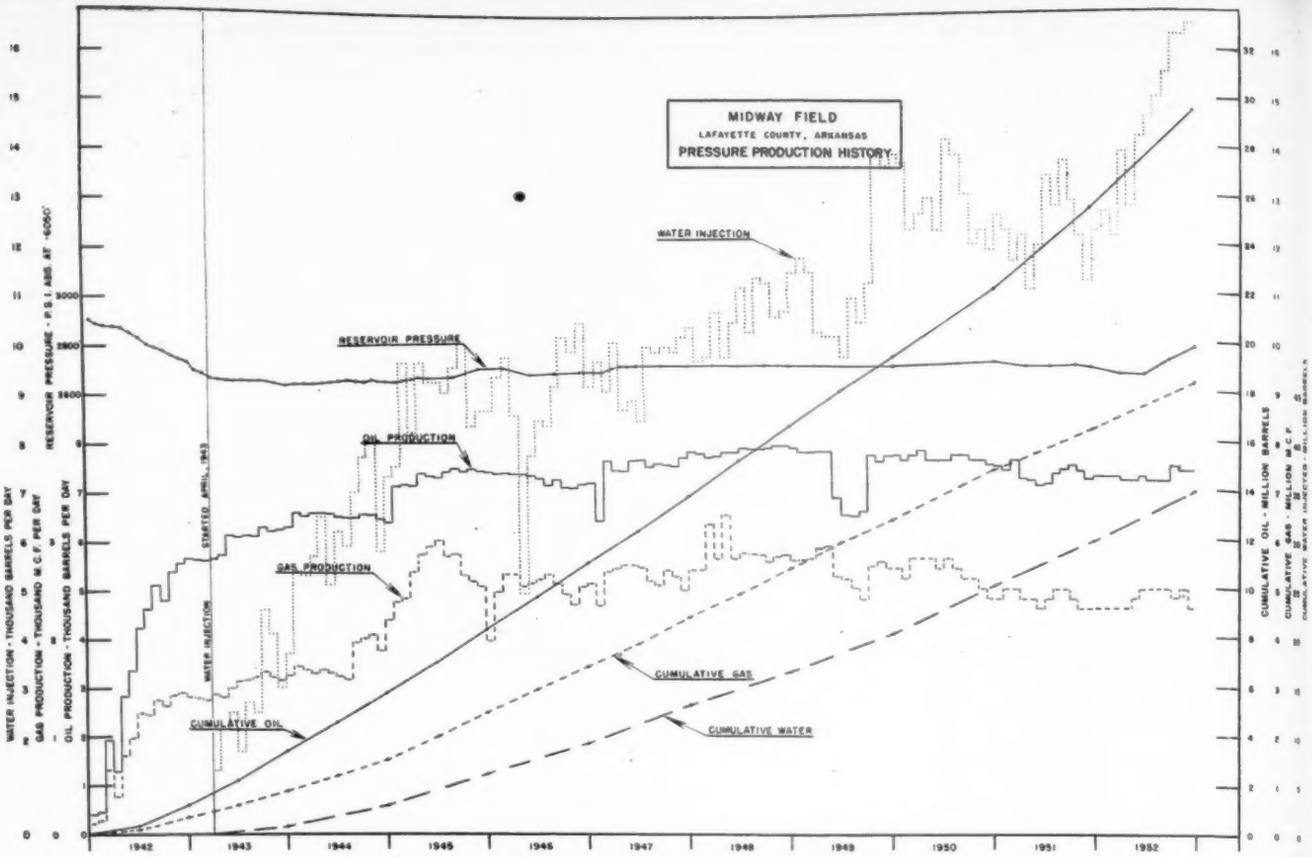
quarter in Arkansas, has a Pettet lime pool situated on a closed anticline. It has had a gas injection project in operation in Louisiana since 1945. The gas is injected into the gas cap of the Pettet lime reservoir, Sligo formation of the Lower Cretaceous, at a depth of about 5400 ft. This gas injection has no appreciable effect on the Arkansas side of the pool. Water injection was begun in 1947 and at present there are 34 input wells of which 9 are in Arkansas. There are at present 34 producing wells over the 2720 allotted acres in Arkansas. The Arkansas side produced in 1952, 197,572 bbl of oil, 183,434,000 cu ft of gas, and 346,020 bbl of water. This represents a decline of 154,580 bbl of oil and 18,802,000 cu ft of gas, and an increase of 94,698 bbl of water from the previous year. The cumulative production to January 1, 1953, has been 3,956,429 bbl of oil, 5,456,145 MCF of gas, and 958,949 bbl of water. There were 834,180 bbl of water injected in 1952, and the cumulative water injected up to January 1, 1953, amounted to 6,637,393 bbl. The original reservoir of the Arkansas part of the pool was estimated to contain 16,000,000 bbl of stock tank oil in place, and the recovery by primary methods about 18 per cent or 2,900,000 bbl of oil. The recovery by gas and water injection, originally estimated around 38 per cent, has been revised downward to about 27 per cent. This gives an estimated 400,000 bbl of proved reserves at the end of 1952. The original bottom hole pressure was 2344 psi and the bottom hole pressure at the end of 1952 was 497 psi, an increase for the year of 184 psi. Decline of the field has been rapid during the year.

**Lisbon Field,** producing from the Nacatoch sand of the Upper Cretaceous around 2100 ft in depth, is located on a structural terrace, with the production controlled more by sand conditions than by structure. This field was practically depleted by primary recovery methods when, in 1949, the field was unitized for the purpose of water injection. The water injection began in May 1949. The production in 1948, the year previous to water flooding, amounted to 29,415 bbl of oil. The production in 1952 was 119,312 bbl of oil as against 111,155 bbl in 1951, an increase for 1952 of 8,157 bbl. The water injected was 2,700,000 bbl. The cumulative recovery to January 1, 1953, was 7,460,944 bbl of oil. The recovery under primary methods was estimated as 7,200,000 bbl of oil, about 15 to 25 per cent of the original stock tank oil in place. It has already produced 260,944 bbl more than the estimated recovery under primary methods. The total recoverable oil under secondary recovery has been estimated as 12,342,000 bbl which leaves a reserve of 4,881,000 bbl. There are 480 acres at present under water flooding with the entire project covering 4946 acres. There were 111 producing wells when the project started but most of these have been shut in or abandoned, with 25 wells producing. The production gives a good idea of the project and indicates the success of water injection.

**The Magnolia Field,** Columbia County, situated on a closed anticlinal fold, produces mainly from the Smackover limestone of Jurassic Age, about 7500 ft in depth. A pressure maintenance and salt water disposal project was begun in 1945. There were 4,103,431 bbl of oil, 4,215,460 MCF of gas, and 2,985,804 bbl of salt water produced in 1952 from the limestone reservoir, while 6,347,580 bbl of water were injected into the reservoir. The field up to January 1, 1953, has produced 72,037,527 bbl of oil, 72,471,761 MCF of gas, and 22,078,082 bbl of water. Water injection up to January 1, 1953, has amounted to 37,434,499 bbl. The original bottom hole pressure was 3465 psi and at the end of 1952 it was 2683 psi, a decline for 1952 of only 15 psi.

A relatively strong water drive existed in the Smackover limestone reservoir before water injection and the amount of increased production due to water injection is difficult to calculate. Injection of the water allows the oil to be withdrawn at a more rapid rate than would have been possible without it. The original reservoir has been estimated as 224,000,000 bbl of oil with about 50 per cent recoverable, which leaves an estimated proved reserve of 39,963,000 bbl of oil.

**The McKamie-Patton Field,** producing from the Smackover limestone of Jurassic Age, around 9300 ft in depth, is located on an east-west anticline in Lafayette County. It is primarily a gas-condensate field with a rim of oil production. The sour gas produced in this field is cleaned, hydrogen sulphide and carbon dioxide removed and the sul-




**Pressure production history of Midway field, Lafayette County, Arkansas.**

fur recovered. The dry gas is then used commercially. The original plant handled about 25,000,000 cu ft of gas and produced up to 75 long tons of sulfur daily. This is the first plant, at least in the United States, to separate sulfur commercially from a hydrogen sulfide gas. The plant was later enlarged to double its capacity, both in gas handled and in the amount of sulfur produced. It is now producing at the rate of about 125 long tons daily.

A gas cycling operation was begun in August, 1949, and water injection started in December 1950. During 1952 the limestone reservoir produced 1,445,431 bbl of oil and condensate, 15,868,176 MCF of gas, and 218,178 bbl of water. The cumulative production to January 1, 1953, has been 13,-271,807 bbl of oil and condensate, and 114,030,506 MCF of gas. Since the beginning of the pressure maintenance project a total of 42,917,885 MCF of gas has been injected into the reservoir, 17,831,335 MCF in 1952. There were 240,780 bbl of salt water injected into the reservoir in 1952. The original bottom hole pressure was 4396 psi and at the end of 1952 about 2354 psi, a drop for the year of about 888 psi.

Reserves at the end of the year were estimated as 41,304,000 bbl of oil and condensate and 238,635,000 MCF of gas. It is estimated that an additional 250,000 bbl of oil, 9,000,000 bbl of condensate, 26,000,000 MCF of gas and 260,000 tons of sulfur will be produced as a result of the pressure maintenance program.

**The Midway Field,** in Lafayette County, is located on an east-west anticline and produces from the Smackover lime of Jurassic Age about 6400 ft in depth. The field was discovered in January 1942 and the pressure maintenance project begun in 1943. This is a Primary Pressure Maintenance Project. The field produced 2,673,595 bbl of oil, 879,951,000 cu ft of gas, and 1,302,284 bbl of salt water during 1952. This is a decrease of 9123 bbl of oil, a decrease of 3,686,000 cu ft of gas , and an increase of 217,535 bbl of salt water from the preceding year's production. The fresh and salt water injected into the reservoir amounted to 5,592,312 bbl. Cumulative production to January 1, 1953 was 27, 433,410 bbl of oil, 9,140,159 MCF of gas and 6,-516,531 bbl of salt water.

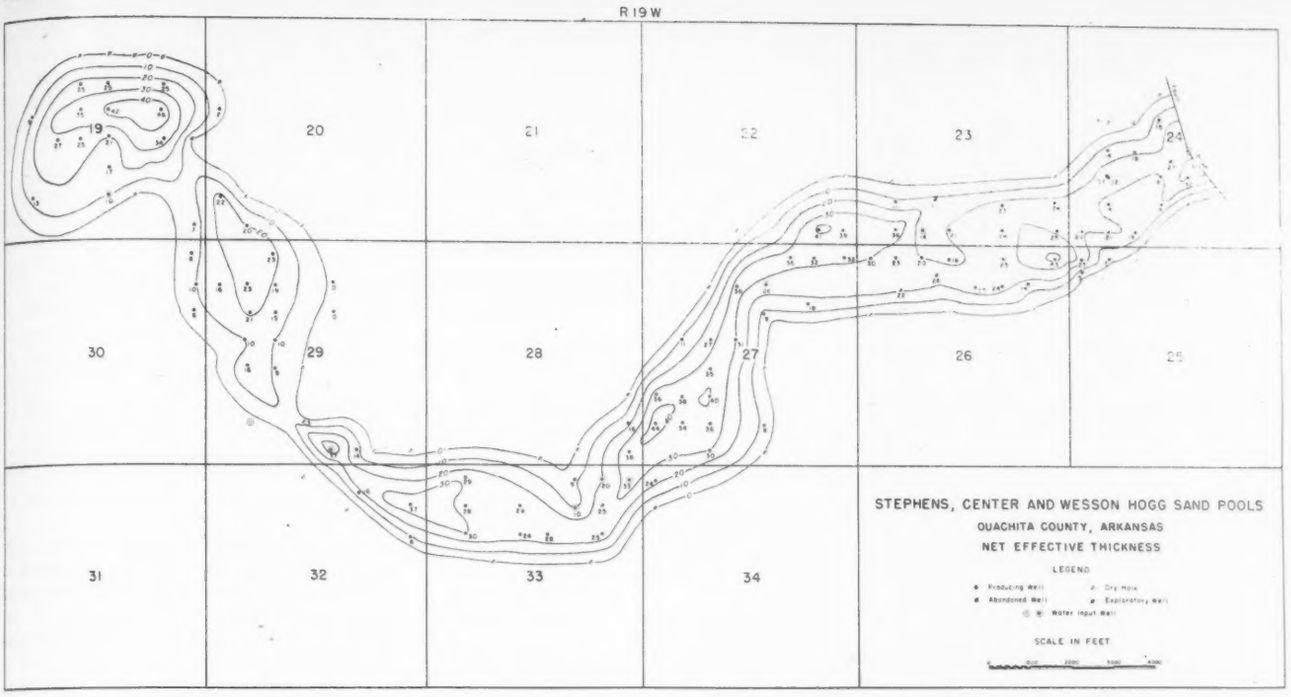
The original bottom hole pressure was 2920 psi, and the bottom hole pressure at the end of 1952 was 278 psi, an increase over 1951 of 81 psi. There are at present 22 flowing wells and 24 wells on artificial lift. This is still one of the most successful pressure maintenance projects in Arkansas.

The original reservoir was estimated at 191,000,000 bbl of oil and 45 billion cubic feet of gas. The recovery by primary methods was estimated at 28,-000,000 bbl of oil, about 14 per cent recovery, and under water injection as between 65 and 85,000,000 bbl of oil, or about 34 to 45 per cent. Estimated reserves at the end of the year are 47,-566,000 bbl of oil, on the basis of 75,-000,000 of recoverable oil and a recovery factor of 50 per cent.

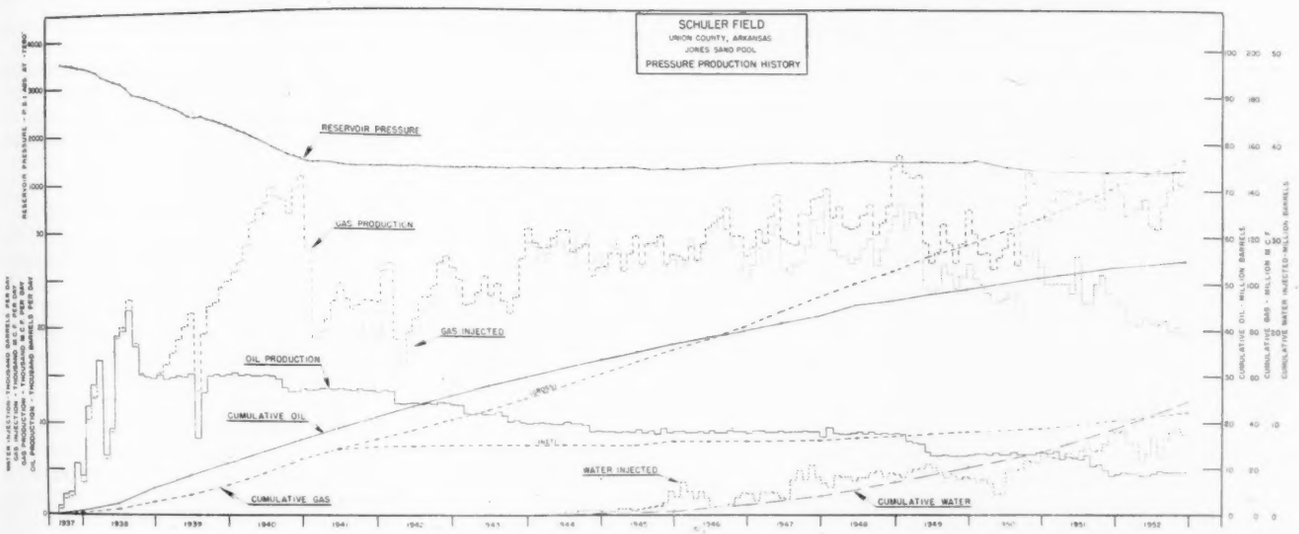
**The Stephens Field,** Ouachita County, Hogg sand pool, about 3240 ft in depth, is in a sand bar on the upthrow side of the Stephens Fault. This sand is at the base of the Pine Island formation of Lower Cretaceous Age. The pool was discovered in May 1949, and has 14 producing wells on artificial lift over an area of about 367 acres. The rapid decline in bottom hole pressure led to the unitization of the field, and water injection started in May 1950. The original bottom hole pressure was 1308 psi and it declined to 294 psi when water injection was started. The bottom hole pressure at the end of 1952 was 953 psi, an increase during the year of 14 psi and an increase of 659 psi since water injection was started. There were 307,440 bbl of oil and 122,281 bbl of salt water produced, and 463,296 bbl of fresh water and salt water injected into the reservoir during 1952. Cumulative output to January 1, 1953, was 1,116,258 bbl of oil and 470,459 bbl of water.

The reservoir was originally estimated to contain 7,750,360 bbl of stock tank oil with primary recovery estimated as 21 per cent or 1,628,000 bbl of oil, and the recovery under water injection as 60 per cent or 4,650,000 bbl, an increase of 3,022,000 bbl due to secondary recovery. The reserves of recoverable oil at the end of 1952 were estimated as 3,534,000 bbl. The results to date are satisfactory.

**The Schuler Field,** Union County, Jones sand pool, is on an anticline covering about 4000 acres. Reservoir lies at the base of the Cotton Valley (Jurassic) formation at an approximate depth of 7400 ft. The pool was discovered in September 1937; unitized in February 1941; gas injection begain in




**Net effective thickness of Stephens, Center, and Wesson Hogg sand pools in Ouachita County, Arkansas.**




**Pressure production history of Schuler field, Union County, Jones sand pool.**

July 1941; and water injection began in June 1944. The Jones sand reservoir in 1952 produced 1,644,759 bbl of oil, 12,391,403 MCF of gas and 502,516 bbl of water.

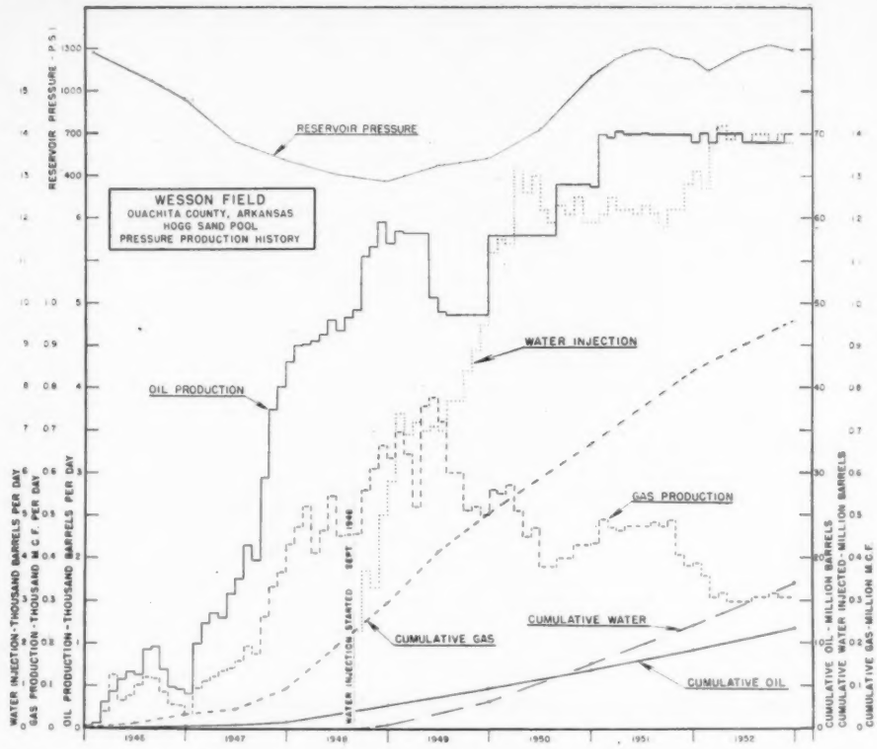
This represents a decline of 466,738 bbl of oil, an increase of 1,773,473 MCF of gas, and an increase of 12,548 bbl of water, as compared to the production of 1951.

During the same period 7,654,703 MCF of gas and 3,431,124 bbl of salt water were injected into the reservoir. The original bottom hole pressure was 3520 psi, and the bottom hole pressure at the end of 1952 was 1423 psi, an increase over the bottom hole pressure of October 1951 of 3 psi. At the end of the year, the cumulative production for the pool was 55,024,684 bbl of oil, 153,081,383 MCF of gas, and 4,919,645 bbl of salt water. At the same time a total of 107,335,741 MCF of gas and 12,778,651 bbl of salt water were injected into the reservoir.

The original reservoir was estimated to contain 99,000,000 bbl of stock tank oil in place. It was estimated that about 35 per cent or 35,000,000 bbl of oil would be recovered by primary methods, and about 65 per cent or about 65,000,000 bbl by injecting gas and water. Estimated proved reserves at the end of the year were 13,976,000 bbl of oil and 42,175,000 MCF of gas. The field has already produced over 55,000,000 bbl of oil and during 1952 averaged over 4500 bbl per day.

**The Wesson Field,** Ouachita County, Hogg sand pool, about 3150 ft in depth and covering about 1542 acres, is located on the upthrow side (south) of two closely spaced faults. The Hogg sand is a narrow sand bar closed on the northeast by the above faults, and lies at the base of the Pine Island formation of Lower Cretaceous Age. The discovery well was completed in January 1946, unitization became effective July 1, 1948, and water injection began in September 1948. Sixty-one wells produced 2,560,584 bbl of oil, 118,720,000 cu ft of gas, and 2,099,698 bbl of salt water during 1952. This represents an increase of 26,643 bbl of oil and 744,722 bbl of salt water over 1951. During this same period six injection wells were used to inject 5,048,834 bbl of water into the reservoir.

The original bottom hole pressure was determined to be 1280 psi at a subsea datum of 2800 ft. Following unitization, pressures were determined on a base of sand datum which required changing the original bottom hole pressure to 1299 psi. All bottom hole pres-




**Pressure production history of Wesson field, Ouachita County, Arkansas, Hogg sand pool.**

sures now reported for the Wesson Hogg sand confirm to this base of sand datum. The bottom hole pressure at the end of 1952 was 1299 psi, the same as the corrected original bottom hole pressure, and an increase of 68 psi over the bottom hole pressure at the end of 1951. The total pressure increase over the lowest pressure recorded on January 10, 1949 is 887 psi.

Cumulative production to January 1, 1953 was 11,915,696 bbl of oil and 4,246,049 bbl of water. Cumulative production since unitization to January 1, 1953 was 11,848,212 bbl of oil. Revised estimate of the reserves of oil at the end of the year was 18,336,788 bbl. Original reservoir was estimated as containing 58,000,000 bbl of stock tank oil with about 52 per cent recovery under water injection. This is about 2.65 times the estimated recovery under primary methods.

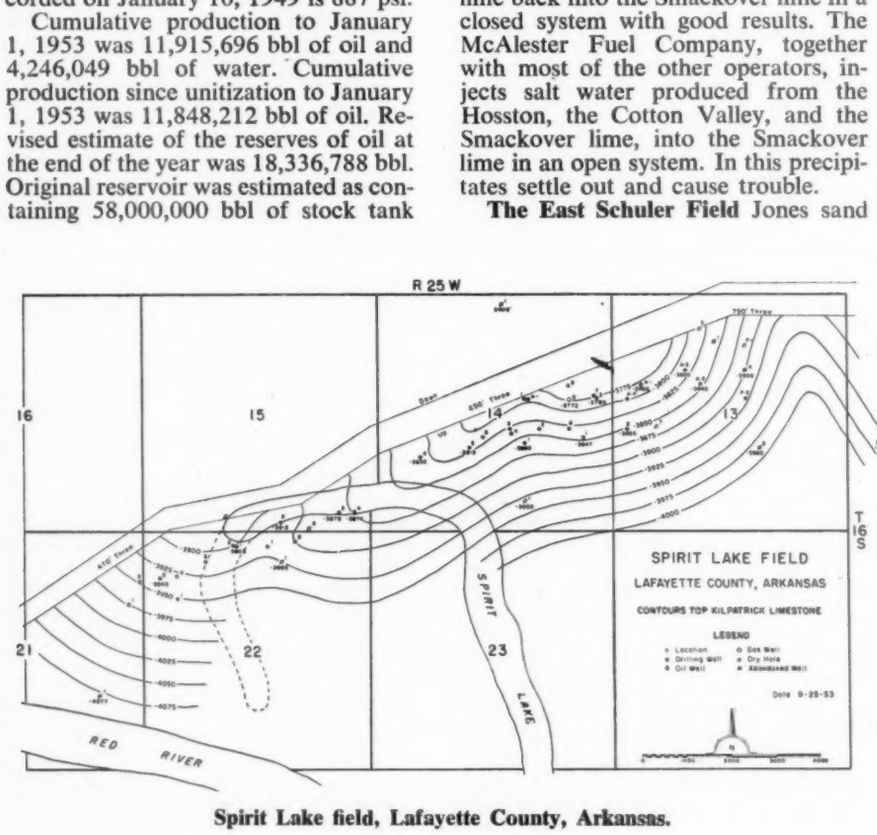
**The Village Field,** Columbia County, has two salt water disposal operations. Pan-Am Southern Corporation, together with Texas Gulf, injects salt water produced from the Smackover lime back into the Smackover lime in a closed system with good results. The McAlester Fuel Company, together with most of the other operators, injects salt water produced from the Hosston, the Cotton Valley, and the Smackover lime, into the Smackover lime in an open system. In this precipitates settle out and cause trouble.

**The East Schuler Field** Jones sand unit was authorized by the Arkansas Oil and Gas Commission on April 17, 1953, in order that pressure in the proposed unit may be maintained by the injection of water, gas or other substance into the producing horizon involved. Curtis Kinard was named as the operator of the unit. The injection of fresh water into one injection well was started April 20, 1953. During May an average of 1669 bbl of water per day was injected into the reservoir, which was an average of 675 bbl of water per day above the reservoir space voided. During June an average of 1817 BWD was injected into the reservoir. The BHP at 7310 ft was 2400 lb. There has been a slight increase in pressure in wells close to the injection well. The operator plans to increase the injection rate and decrease pressure by the use of chemicals.

**Stephens Field's** work on the secondary project for the Center pool is going ahead. Gathering lines are being laid. McAlester Fuel Company is injecting water into the sand until the project is completed.

**West Midway Field**—the unitization project for the Smackover Reservoir has still considerable work to do. They have to get the necessary signatures and agreements, and so far their plans are not completed.

The U. S. Bureau of Mines is making a study of the Buckrange sand in the Stephens field to determine the possibilities of that sand for a water injection program.




**Spirit Lake field, Lafayette County, Arkansas.**

## Exploration and Drilling

Geophysical activity, confined principally to South Arkansas, declined from 431 crew weeks in 1951 to 271 crew weeks in 1952. The geophysical activity can be further divided into 252 crew weeks for seismograph and 19 crew weeks for core drilling.

There was a slight increase in drilling activity for the state due to a slight increase in drilling in Northwest Arkansas. There were 426 wells drilled in the state as against 411 in 1951, most of these in South Arkansas. There were 402 wells drilled in South Arkansas this year as against 398 in 1951. Of these 287 were field wells and 115 were wildcat wells. This drilling resulted in 206 producing wells and 196 dry holes. There were also 97 recompletions and 99 old wells abandoned in South Arkansas.

There were a total of 24 wells drilled in Northwest Arkansas in 1952 as against 13 in 1951. There were 15 field wells and 9 wildcat wells. These wells resulted in 12 gas wells and 12 dry holes for the year. There was only 1 old well abandoned during the year.

The greatest number of wells drilled was in the old Smackover field, where 18 oil wells and 11 dry holes were completed. The next was the Springhill field of Columbia County where 21 oil wells and 3 dry holes were completed. Then came the Ezzell pool of the East El Dorado field with 13 oil wells and 5 dry holes. This was followed by Lewisville-West with 10 oil wells and 6 dry holes, Champagnolle field with 11 oil

EARLY METHOD of transportation—Smackover field. Author saw this ox team stuck in a mud hole with same load as above.

wells and 3 dry holes and Fouke with 10 wells and 3 dry holes.

### New Fields and New Extensions

There were 17 wildcat wells which resulted in the discovery of new fields or extensions to old fields during 1952. Twelve of these are listed as discovery wells of fields and 5 of extensions. This is a considerable increase over the 10 new fields or extensions discovered in 1951. These discoveries, though encouraging, are not believed to be of major importance.

New fields and new extensions are:

**Artesian Field** (Calhoun County).

First discovery of the year was the Artesian field of Calhoun County. The discovery well, the Alcan Oil Company's Freeman-Smith No. 1, 480 ft S 990 ft W NEc SE 17-15-15, was completed January 1, 1952. This well was started by McAlester Fuel Company and taken over and completed by the Alcan Oil Company. The well was drilled to 2580 ft and pumped initially, through perforations between 2561-76 ft in the Meakin sand, 25 bbl oil daily with a gravity of 16 deg. Five additional producing wells and one dry hole were completed during the year. This field is on the north and upthrow side of a northwest-southeast fault.

**Moro Bay Field** (Calhoun County).

The Moro Bay field was brought in in August by B. E. Hill et al in their Freeman-Smith Land Company No. 1, 300 ft E 330 ft NWc NE SE 14-16-13. It is located on the upthrow side of a fault. The well was drilled to a depth of 3495 ft and produced initially on the pump through perforations in the Cotton Valley between 3462-70 ft, 150 bbl oil per day 5 per cent water and a gravity of 13 deg. No other wells were started during the year.

**Horsehead Field.** (Columbia).

This field was discovered by the McAlester Fuel Company's Sam J. McCollum A-1, C NW NE 22-19-21. The well was drilled to a depth of 11,296 ft in the Smackover lime, then plugged back and a producer completed in the Pettet lime. It flowed initially through perforations 3850-58 ft, 5861-64 ft, and 5866-77 ft and through a 14/64-in. choke, 79 bbl oil per day of 38 deg gravity. This well was completed in February. One additional oil well and two dry holes were completed during the year.

**Springhill Field** (Columbia County).

Discovery of this Tokio sand field was made during the drilling of the Shell Oil Company and Mid-Continent Petroleum Corporation's Browning-Burns Unit No. 1, 660 ft N and W SEc 12-20-23, a deep test. The well found productive sand but continued on to 12,646 ft in the Buckner, then plugged back and a well made in the Tokio.

The first producer in this field was on the Louisiana side, but the first producer on the Arkansas side was Pan-Am Southern Corporation's Lucy Burns et al No. 1, 330 ft N and E SWc 7-20-22. It was drilled to 3104 ft and came in flowing through perforations in the Tokio sand between 3099-3103 ft. It made initially 192 bbl oil per day through 20/64-in. choke, of 39.6 deg gravity oil and a gas oil ratio of 200:1. There have been in all, 21 oil wells and 3 dry holes completed during the year.

**North Stamps Field** (Lafayette).

The North Stamps field was discovered by the McAlester Fuel Company's B. L. Williams A-1, 200 ft N C SW SE 5-16-23, on the upthrow side of a fault. It was drilled to 4020 ft and pumped initially through perforations 2364-73 ft in the Tokio sand, 12 bbl oil per day of 14.7 deg gravity. The well came in in July and since then one dry hole, southeast of the discovery well, has been completed.

**Falcon Field Extensions** (Nevada and Lafayette counties).

The Russell extension of the Falcon field is in a graben about a mile northwest of the Falcon fault. It was brought in by the Arthur Russell, Arthur Russell No. 1, C SW SW NE 8-15-22. It was drilled to 1664 ft and pumped initially, open hole from 1646-64 ft, in the Nacatoch sand, 40 bbl oil per day, 30 per cent SW. This producing depth is about 450 ft deeper than that of the Nacatoch sand on the upthrow side of the fault. The discovery well was completed in January, and since then one more producing well and 3 dry holes have been drilled.

Another extension along the fault and a new oil pay in this field was discovered by Sneed Brothers in their A. L. Armstrong Fee No. 1, C NW NW 10-15-22. The well was drilled to a depth of 3363 ft and perforated between 2692-97 ft in a sand of the Rodessa formation, a new producing horizon in this field. It pumped initially 41 bbl oil per day of 32 deg gravity. This well extended the field to the northeast. It was completed in December and there has been no confirmation test started before the year's end. Two Nacatoch wells and one dry hole were drilled during the year in Section 10-15-22, extending the field a short distance to the northeast and limiting it on the east by the dry hole.

**Doddridge Field** (Miller County).

This field was discovered by W. G. Skelley's Dickson Heirs No. 1, 1295 ft S 1424 ft E NWc 36-19-27, on a fault line play, in May. It was drilled to 11,079 ft in the Cotton Valley formation, then plugged back and perforated between 6828-40 ft in the Pettet lime. It flowed initially 132 bbl oil per day, on ¼-in. choke of 36.8 deg gravity. A well one-half mile east was drilling at the close of the year.

**Fouke-West Field** (Miller County).

The discovery well of this fault line field was the Jay Simmons, S. G. Dildy No. 1, 660 ft E 330 ft S NWc SW NW 21-17-27. It was drilled to a depth of 4306 ft and flowed initially, through open hole from 4302-06 ft in a sand of the Paluxy formation, 400 bbl oil per day, ¼-in. choke, of 35 deg gravity. This well was completed in August and since then 2 dry holes have limited the area to the north and northeast along the fault. An east offset to the discovery well was drilling at the end of the year.

**Buena Vista Field** (Ouachita).

The discovery well of the Buena Vista field was the Alcan Oil Company's Mary Slaughter No. 1, 800 ft N 330 ft E SWc SE SW 14-14-19. It was drilled to 2000 ft and came in pumping initially through perforations 1962-76 ft, 66 bbl oil per day of 29 deg gravity, and no water. An east offset to the discovery well was dry. This faulted area had many tests before the discovery well came in.

**East Pace City Field** (Ouachita).

This field was discovered by the Harris H. Pace, J. W. Coan et al, Reynolds Gammill Lumber Company No. 1, C NW SE 28-15-17. It was drilled to 4009 ft, plugged back and pumped initially through perforations between 2409-15 ft in the Graves sand, 22 bbl oil per day of 19 deg gravity, 25 per cent water. This field is just west of the old Smackover field and on the southeast and upthrow side of a northeast-southwest fault. There have been 6 additional oil wells and 6 dry holes drilled during the year, since the discovery in August.

**Wesson-North Extension** (Ouachita).

This unimportant extension was completed in March, by the Stephens Producing Company in their C. and R. Wesson A-1, 75 ft NW C NE SE SW 3-15-19. It was drilled to 1375 ft and

pumped initially through open hole 1370-75 ft, 12 bbl oil per day of 13 deg gravity, 4 per cent water. This well was drilled near a former deep test which had a show in the Nacatoch, the producing sand and cut a fault at 1000 ft. There has been no more drilling during the year.

**Calion Field** (Union County).

The Calion field was discovered by the Kirby Petroleum Company's Southern Company No. 1, C SE SW NW 18-16-14, in November. It was drilled to 3543 ft in the Travis Peak, plugged back and perforated 2599-2612 ft in the Blossom. It pumped initially 51 bbl oil per day of 22 deg gravity. Two additional wells, one in the Blossom sand and the other in the Graves sand, were completed in December. This field is just southeast of the Smackover field on a separate dome structure.

**South Hibank Field Extension** (Union County).

The South Hibank extension was brought in in May by the Lawton Oil Corporation, after drilling 3 dry holes on the same 40 acres as the discovery well. The discovery well was their Union Saw Mill Lumber Company B-4, 574 ft W 630 ft N SEc SW SW 35-18-14. It was drilled to 3519 ft and came in flowing initially through open hole 3480-3519 ft in a sand of the Travis Peak formation, 150 bbl oil per day, of 33.7 deg gravity through 12/64-in. choke. There have been 5 additional oil wells and 4 dry holes completed during the year. All the completions were in sands of the Travis Peak or Hosston formation.

**Schuler Field Extension** (Union).

A new producing horizon and an extension to the Schuler field was discovered by the Carter Oil Company's E. M. Wooley No. 1, 532 ft S 650 ft W NEc 28-18-17. The well was drilled to a depth of 4200 ft and produced initially through perforations in the Tuscaloosa sand between 3104-18 ft, 47 bbl oil per day of 35 deg gravity, 30 per cent water, on pump. This well extended the field about a mile to the southeast and opened a new oil pay for the field. There were no new developments at the end of the year. The well was completed in October.

**Urbana-North Field** (Union).

The Urbana field was extended to the north by Curtis Kinard's Union Saw Mill 1-A, 100 ft N C SE SE SW 34-17-13. It was drilled to 3605 ft and pumped initially through perforations in a Travis Peak sand from 3337-51 ft, 34 bbl oil per day. The well was completed in February and since then 5 more oil wells and 1 dry hole have been completed in the Travis Peak or Hosston formation.

### New Reservoirs and Extensions

**Lewisville-West Field** (Lafayette).

This field was extended a little east along the fault, about a half mile, by 5 Tokio wells and 1 Mooringsport well. It was extended a little west by 1 Tokio well and then limited on the west by a dry hole. The field was extended south by 2 Tokio wells and limited on the south by 3 dry holes. There were 10 oil wells and 6 dry holes completed, and 2 old wells abandoned during the year.

**Fouke Field** (Miller County).

The Carter Oil Company in their W. P. Sturgis No. 19 introduced a new pay horizon to the field. The well was drilled to a depth of 3022 ft and completed in the Tokio sand through perforations 2955-60 ft in October. It pumped initially 34 bbl oil per day of 20 deg gravity and 2 bbl water per day. There were no other completions in the sand during the year.

This field was active during the year due to the development of a sand of the Paluxy formation. There were 9 oil wells completed in the Paluxy and 3 dry holes abandoned, also 2 recompletions and 1 old well abandoned during 1952.

**East El Dorado Field** (Union).

A new producing sand and an extension to the Ezzell pool of the East El Dorado field was brought in in October. The Beckman Inc. et al, Wilson et al No. 1, C SE SW SE 14-17-15, was drilled to 2500 ft and flowed initially through perforations in the Meakin sand between 2491-95 ft, 20 bbl oil per day of 24 deg gravity with 36 per cent water. There were no new developments at the year's end.

**Hibank Field** (Union County).

The Hibank field was extended about a half mile to the northwest along the Hibank Fault, and a new oil reservoir discovered by the McAlester Fuel Company's H. D. Pendleton A-1, C SE SW NE 24-18-15. It was drilled to a depth of 3537 ft and flowed initially through perforations in the Graves sand between 2556-58 ft, 85 bbl oil per day of 32 deg gravity, and .8 per cent B S and water through 16/64-in. choke. This well, completed October 17, was followed by the McAlester Fuel Company's H. G. Pendleton A-2, C SW SW NE 24-18-15, completed on October 26. This well introduced still another pay horizon for the field. It was drilled to 2596 ft and perforated between 2434-36 ft in the Meakin sand, flowing initially through 12/64-in. choke, 136 bbl oil per day of 30 deg gravity. Another well in the Meakin sand was completed in this section, 24-18-15, and another started during the year. A dry hole was drilled and abandoned in September in this same section, 24-18-15, before the new pays were discovered. A dry hole was also drilled to 3800 ft in Section 29-18-14, along the fault between the Hibank and South Hibank fields, and abandoned in December.

### Discoveries and Fields Abandoned During the Year

**Canfield Field** (Lafayette County).

The Canfield field was discovered in February by the California Company's P. D. Burton No. 1, C NE NE 9-18-13. It was drilled to 9555 ft in the Smackover lime, then plugged back and completed in a sand in the Cotton Valley formation. It flowed initially through perforations between 7342-52 ft, 279 bbl oil per day of 42 deg gravity on ¼-in. choke. This well was temporarily abandoned in July. A northeast offset in Columbia County was drilled and abandoned in the Smackover lime at 9315 ft in October.

**South Hibank Field** (Union County).

The discovery well of this field, the Murphy Corporation's Robertson A-1, 657 ft E 667 N SEc SE NE 33-18-14, came in a producer in a sand of the Travis Peak formation in August of 1951. This well was abandoned in July 1952.

A new pay, the Pettet, was discovered in the field in January by Murphy Corporation's Sallie No. 1, C SW SW NW 34-18-14, a dual completion. It came in a gas well through perforations 3511-14 ft in the Travis Peak making initially 1,482,000 cu ft per day, and through perforations 3431-34 ft in the Pettet lime making initially 1,000,000 cu ft per day. This gas well was abandoned in July 1952.

These were the only two wells in the original South Hibank field, on the upthrow or south side of the Hibank fault, and as a result of their abandonment, this original part of the South Hibank field is abandoned. The name is now applied to the extension to the southeast along the fault, brought in by the Lawton Oil Corporation in Sections 34 and 35-18-14.

**Unnamed Field** (Union County).

The wildcat well drilled by Martin Wunderlich, the Reynolds Gammill Lumber Company No. 1, 160 ft W C SW NW 36-16-17, was drilled to a depth of 6588 ft. It flowed initially through perforations 6425-28 ft in the Smackover lime, 100 bbl oil per day. It stopped flowing and on the pump made 6 bbl oil per day and 94 bbl water per day. The well was plugged and abandoned in July.

**Wilks Field** (Union County).

This field was rediscovered by C. H. Murphy and Company in their Gottschall No. 1, 540 ft N 620 ft W SEc NE SE 3-18-18 in 1951. The well and the field were abandoned in July 1952.

### New Fields to August 15, 1953

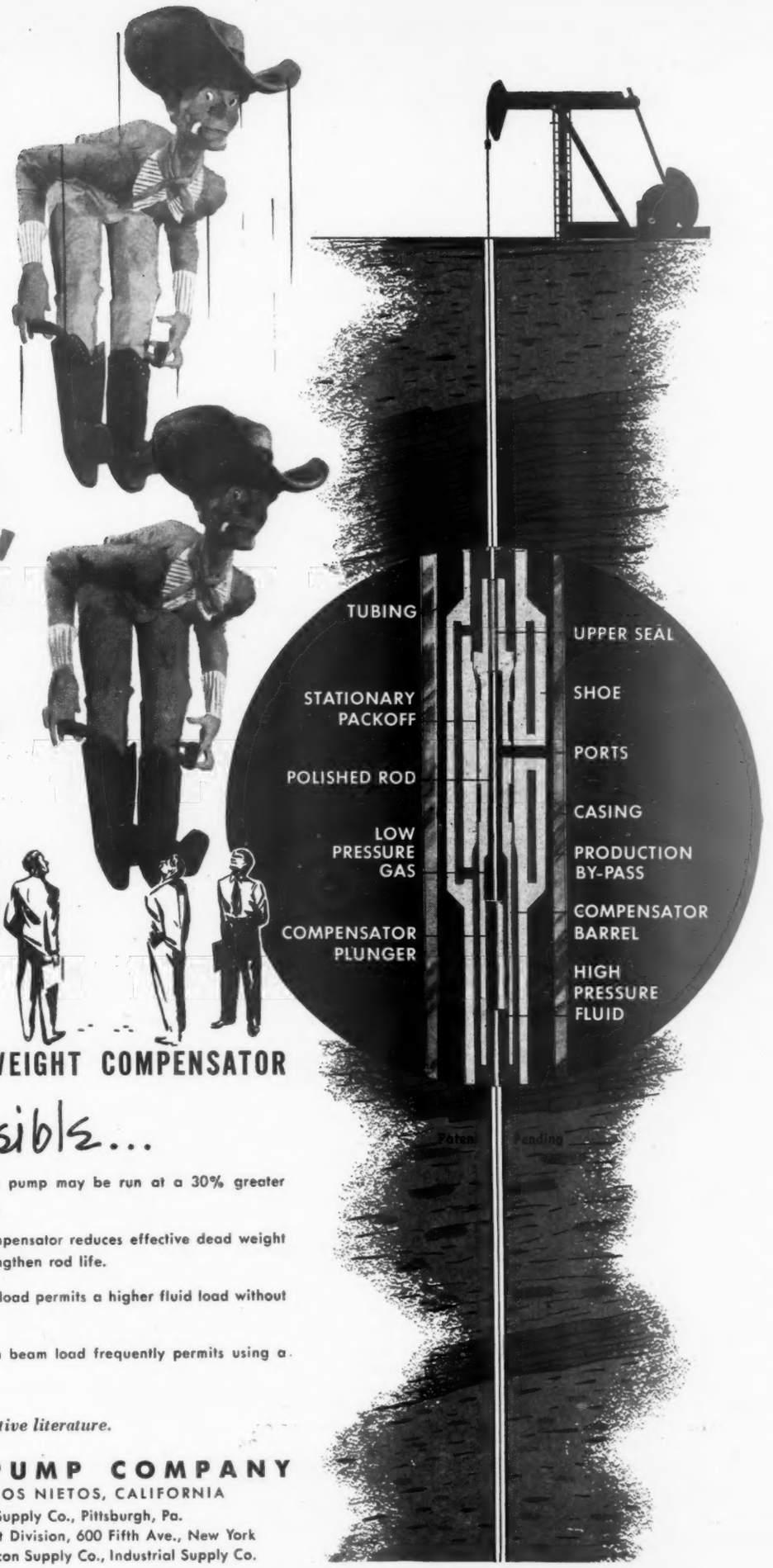
There were nine wildcat wells that resulted in the discovery of new fields up to August 15 in 1953, none of major importance.

**East Atlanta Area** (Columbia).

This field was discovered by the Murphy Corporation-Birtie No. 1 in C SW NE 6-19S-18W, a few miles east of the town of Atlanta. The well was drilled to a depth of 8773 ft in the Smackover lime, 5½-in. casing was set at 7705 ft and perforated between 7588-98 ft in a Cotton Valley sand of Jurassic Age. The initial production was 72 bbl oil per day with 4/10 per cent water and 34,600 cu ft gas through 12/64-in. choke. The well was completed July 16, 1953.

**Boggy Creek Field** (Miller County).

This field was discovered by the Tom Palmer-Fouke Estate No. 1 in the C SE NE NE 24-17S-28W, completed August 5, 1953. The well was drilled to a depth of 5020 ft, 5½-in. casing set at that depth and perforated between 4889-93 ft in the Paluxy formation of Lower Cretaceous Age. The initial production was 108 bbl oil per day of 30.5

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**Center Pool** (Ouachita County).

This Hogg sand pool of the Stephens field lies between the Stephens Hogg sand pool to the north in Section 19, and the Wesson Hogg sand pool to the south in Section 32. The Hogg sand is a sand bar located on the south and upthrow side of the Stephens fault. This sand lies at the base of the Pine Island formation of Lower Cretaceous Age. The field was brought in January 10, by the Sneed Brothers-J. H. Hughes Estate No. 1 in the C NW SE NW 29-15S-19W. The well was drilled to a total depth of 3215 ft, 7-in. casing set at 3215 ft and perforated between 3178-91 ft in the Hogg sand. The initial production was 240 bbl oil per day, flowing, of 31 deg gravity. The bottom hole pressure at 2984 ft was 1497 lb. Up to date there have been 16 oil wells and 3 dry holes completed in the pool.

**North Lewisville Area** (Lafayette County).

The discovery well was completed July 4, 1953 and produces from the Tokio formation of Upper Cretaceous Age. It was brought in by the Burnett Production Company-Allie Boyette A-1 in the C SE NE SE 33-15S-24W. The well was drilled to a total depth of 5224 ft, 5½-in. casing set at 2900 ft and perforated opposite the Tokio sand between 2819-21 ft. The initial production on the pump was 21 bbl oil per day of 22 deg gravity, and 84 per cent water. The oil is accumulated against a fault. Three dry holes have been drilled to the west and southwest of the discovery, one in the west 10 acres.

**East Lisbon Field** (Union County).

This field was discovered on March 17, 1953, by the completion of the Don Montgomery et al-Brasher No. 1 in C SW NE 14-17S-16W. It was drilled to a depth of 6818 ft in the Smackover lime, 5½-in. casing set at 5025 ft and perforated between 4941-50 ft. It flowed initially 140 bbl oil per day through 10/64-in. choke of 47.6 deg gravity. This well was reworked and abandoned on June 16, and a west offset was a dry hole.

**North Lisbon Field** (Union County).

Discovery well of this field, the Leonard W. Phillips-Clemmie M. Bishop No. 1 in C NE SE 25-16S-17W was completed in the Smackover lime on June 14, 1953. The well was drilled to 6403 ft in the Smackover lime, 5½-in. casing set at 6400 ft and perforated between 6398-6400 ft in the Smackover lime of Jurassic Age. It pumped initially 109 bbl oil per day of 25.8 deg gravity. A south offset completed August 10 was dry and abandoned.

**West Midway Field** (Lafayette County).

This field is a few miles west of the Midway field, and produces from the Smackover lime of Jurassic Age on a closed anticlinal structure. It was brought in by the McAlester Fuel Company-Clifford McDonald B-1, located 731 ft S and 589 ft W NEc NW 7-15S-24W on February 18, 1953. The well was drilled to 6647 ft, 5½-in. casing set at 6644 ft and perforated between 6569-81 ft in the Smackover lime. The well flowed initially 276 bbl oil per day through 16/64-in. choke, with a tubing pressure of 200 lb, a gas/oil ratio of 820:1 and the gravity of the oil was 30.5 deg. Three additional wells and one dry hole have been completed up to August 4.

**North Mt. Holly Field** (Union County).

This oil pool was discovered by the Murphy Corporation-Woodward No. 1 in the C SW NE 22-16S-18W and completed on July 4, 1953. It was drilled to 6933 ft in the Smackover lime of Jurassic Age, 7-in. casing set at 4509 ft and perforated between 4445-47 ft in a sand of the Hosston formation of the Lower Cretaceous. It pumped initially 40 bbl oil per day, 96 per cent water, and 39 deg gravity.

**Pigeon Hill Field** (Union County).

The field was brought in by the Carter Oil Company-S. M. Goodwin et al No. 1 840 ft N 700 ft E SWc SW NW 28-16S-12W, and completed on January 27, 1953. The well was drilled to 5100 ft in the Smackover lime, 7-in. casing set at 4757 ft and perforated at 4287-97 ft and 4300-01 ft. The well pumped initially 53 bbl oil per day, 9 per cent water and 15 deg gravity.

## New Oil Pays Discovered in 1953 To Middle of August

**Calion Field,** Nacatoch sand (Union County).

The Kirby Petroleum Company-Southern Company B-1, located 330 ft S and E NWc NW SW 18-16S-14W, completed January 5, 1953 in the Nacatoch sand of the Upper Cretaceous, opened a new pay sand for the field. It was brought in through perforations between 2092-96 ft and flowed initially 2 bbl oil per day and 80,000 cu ft gas per day through ⅛-in. choke, with a gas/oil ratio of 40,000:1 and a gravity of 15 deg.

**Champagnolle Field,** Cotton Valley Pay (Union County).

A new pay sand for the Champagnolle field was discovered by the Curtis Kinard-J. W. Taylor B-1, located 260 ft N 65 ft W SEc NW SE 10-17S-14W in a sand of the Cotton Valley formation of Jurassic Age. The well was drilled to 4310 ft and brought in flowing, through perforations between 4134-40 ft. It made initially 18 bbl oil per day through 12/64-in. choke of 32.5 deg gravity and was completed July 12, 1953.

**East El Dorado Field,** Rogers Area, Tokio Pay (Union County).

The Smackover Producing Company-Paraffin-Ezzell No. 1 located 50 ft N C NE NW NW 24-17S-15W and completed June 11, 1953, discovered a new pay sand for this area—the Tokio sand of the Upper Cretaceous. It flowed initially 71 bbl oil per day, 1 per cent water, through perforations between 2901-05 ft and through a ¼-in. choke. Tubing pressure was 40 lb and the gravity 21.3 deg. A southwest offset was dry.

**West Fouke,** Tuscaloosa Pay (Miller County).

The Murray Petroleum-H. T. Lorena Wiegel No. 1 in the C NW SE NW 21-17S-27W completed January 24, 1953, found a new pay sand for the field—the Tuscaloosa sand of the Upper Cretaceous. This was formerly believed to be a sand of the Upper Paluxy formation of Lower Cretaceous Age. It flowed initially 390 bbl oil per day through perforations between 3582-85 ft and through a 16/64-in. choke. Tubing pressure was 150 lb and the gravity 33.5 deg. Former production in this field was from the Paluxy formation of Lower Cretaceous Age.

**Hibank Field,** Tuscaloosa and Hogg Sand Pays (Union County).

There were two pay zones opened up in this field in February. The most important was the Tuscaloosa pay found in McAlester Fuel Company-H. G. Pendleton A-4 in the C SE SW NW 24-18S-15W. It flowed through perforations 3054-56 ft and 3058-60 ft and through 10/64-in. choke, 34 bbl oil per day, 5 per cent water with a tubing pressure of 40 lb and a gravity of 47.2 deg. Eight additional Tuscaloosa wells have been brought in up to the middle of August, six flowing wells and two pumpers.

The Hogg sand pay was discovered by the Murphy Corporation-Lumber No. 1 280 ft N and E SWc SE NE 24-18S-15W. It flowed 125 bbl oil per day through perforations between 3147-54 ft and through a 12/64-in. choke, with a tubing pressure of 430 lb and 45 deg gravity. It was completed on February 11, 1953. So far it is the only Hogg sand well in the field.

**Irma Field,** Rodessa and Hosston Pays (Nevada County).

This Nacatoch field on the upthrow side of the Irma Fault was given new life by the bringing in of two new pay sands in 1953. The Ranney Exploration Company-J. D. Reynolds Company No. 1 in the C SW SE SW 31-13S-20W found a new pay in a sand of the Hosston formation of Lower Cretaceous Age. It came in a pumper, through perforations between 3016-22 ft, and made initially 103 bbl oil per day, 43 per cent water and 28.8 deg gravity. The well was completed April 30, 1953 and is the only producer from this pay to the middle of August. The Berry Asphalt Company-Grove Land and Timber Company D-3 in the C NW NW NE 6-14S-20W, completed June 4, 1953, found a new pay sand in the Rodessa formation of the Lower Cretaceous. It pumped initially 7 bbl oil per day and 200 BSWD through perforations between 2305-08 ft. It is the only completion in this pay sand up to the middle of August.

**East Schuler Field,** Tuscaloosa Pay (Union County).

A new pay sand for this field was discovered by the Curtis Kinard-Janet Johnson No. 1 in the C SW NE 11-18S-17W, completed March 16, 1953. It lies between the Cairo and East Schuler fields. It was drilled to a depth of 7890 ft in the Smackover lime and abandoned. Later the well was cleaned out and 5½-in. casing set at 3352 ft. Casing was perforated between 3090-93 ft and the well came in flowing 135

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bbl oil per day, 25 per cent water, through ¼-in. choke, with a tubing pressure of 75 lb and a gravity of 36 deg. An offset to this well was dry and abandoned.

**Springhill Field,** Hill Pay (Columbia County).

The Hunt Oil Company-B. L. Dennis No. 2, situated 3072 ft S 2353 ft E NWc 11-20S-23W, discovered a new pay in this Tokio sand field, the Hill sand of the Rodessa formation of Lower Cretaceous Age. The casing set at 5916 ft was perforated between 5025-35 ft, 5052-58 ft, and 5068-75 ft and came in flowing 222 bbl oil per day through ¼-in. choke. The tubing pressure was 150 lb and the gravity 43.8 deg. This well, completed February 17, 1953, is the only Hill sand producer in the field.

**Smackover Field,** Hosston Pay (Union County).

The first Travis Peak or Hosston production was brought in by R. M. Crabtree and R. C. Jones-Alphin No. 1 in the C NW NE NW 11-16S-15W, completed April 10, 1953. It pumped initially, through perforations between 3100-20 ft, opposite a sand of the Hosston formation of the Lower Cretaceous, 162 bbl oil per day of 32 deg gravity. Eight additional wells have been brought in as producers and two dry and abandoned up to the middle of August. It opens up new possibilities for oil accumulation on the truncated Hosston formation on the Smackover faulted anticline.

### Gas Production

Northwest Arkansas produces dry gas only from lenticular sands of the thick Atoka formation and from a sandy limestone of the Hale formation, both of Pennsylvanian Age. There were 26 gas fields in Northwest Arkansas at the end of 1952. Some of these were not producing gas due to a lack of pipe line facilities. Cumulative production from these fields to January 1, 1953, is approximately 224,418,737 MCF. There was a considerable increase for the year of 2,175,923 MCF with 10,358,630 MCF produced in 1952, as against 8,182,707 MCF produced in 1951.

There were nine wildcat wells drilled in Northwest Arkansas during the year. Two of these wells were the discovery wells of new gas fields and seven were dry holes. The 15 field wells drilled resulted in 10 gas wells and 5 dry holes. This gives a total of 24 wells, of which 12 were gas wells and 12 dry holes, as against 13 drilled in 1951, of which 7 were gas wells and 6 dry holes.

### New Gas Fields of 1952

**Linville Field** (Johnson County).

This field was brought in in April as a dual completion from sands of the Atoka formation, on the Linville anticline. The discovery well was the Pure Oil Company, Low Gap Unit No. 3, 2030 ft S 560 ft E NWc 30-11N-24W. The well was drilled to a total depth of 1643 ft in the Pitkin limestone, 5½-in. casing set at 1338 ft and produced through perforations 825-40 ft with an initial production of 238,000 cu ft per day, and through perforations 1311-26 ft with an initial production of 462,000 cu ft per day, or a total production of 700,000 cu ft a day of dry gas. This well has no pipe line outlet so is shut in.

**Ozone Field** (Johnson County).

This field was brought in in October from a sandy phase of the Hale formation, on the Ozone anticline. This anticline, though irregular in shape, has a general east and west trend. Discovery well was the Pure Oil Company, Low Gap Unit A-4, 305 ft N 1650 ft W SEc 6-11N-23W. It was only 25 ft south of the Pure Oil Company, Low Gap Unit No. 4, which was junked and abandoned at a depth of 434 ft. The discovery well was drilled to a depth of 2405 ft in the Pitkin lime, and plugged back to 2392 ft. It was shot with 100 qt of nitro-glycerin between 2342-92 ft and produced initially 1,086,000 cu ft per day of dry gas. There is no pipe line outlet for this well so it is shut in.

### Development

There were 15 wells drilled in the gas fields of Northwest Arkansas during 1952—10 gas wells and 5 dry holes, also one old well was abandoned. Eight of the wells extended the fields in which they were drilled, and one of these was also the discovery well of a new producing horizon. Two of these extension wells, in the Cecil field, the Arkansas-Louisiana Gas Company, Lain D. Morris No. 1, and the same company's Sarah Ann Tankersley No. 1, came in with an initial production of 76,500,000 cu ft per day and 75,400,000 cu ft per day of dry gas respectively. These two are the largest gas wells brought in in Northwest Arkansas.

There was an increase in drilling in Northwest Arkansas in 1952. There were nine wildcat wells drilled as against 5 in 1951, and 15 field wells, as against 8 in 1951. The lease play which started in 1951 by the Superior Oil Company's well in Haskell County, Oklahoma, and extended eastward into Arkansas and the Arkansas Valley, was continued for a considerable part of 1952. This play was also extended to the southeast, into the coastal plain of east central Arkansas. This eastern play will be further extended in 1953.

**Rudy Field** (Crawford County).

The Rudy field, discovered in 1949 and located on an anticline, was extended about a half mile to the southeast by the Arkansas-Oklahoma Gas Company, Perry Arnold No. 1, 490 ft N 1320 ft E SWc N½ SE 29-10N-31W. This well produced initially 6,000,000 cu ft per day through perforations 1495-1518 ft in the Atoka formation. The field was limited on the north by a dry hole, the Arkansas-Oklahoma Gas Company, Cy Carney No. 1, 1060 ft N 1620 ft W SEc 20-10N-31W. This well was dry and abandoned at a total depth of 2150 ft.

**Cecil Field** (Franklin County).

The Cecil field, discovered in 1949 and situated on an east and west faulted anticline, was developed and extended by four dual completions and limited to the northeast by a dry hole.

The Arkansas-Louisiana Gas Company, Lain D. Morris No. 1, 330 ft S and E C 24-9N-29W, was completed in January with an initial production of 1,500,000 cu ft per day through perforations 4008-26 ft in the Atoka formation, and 75,000,000 cu ft per day through perforations 2162-2241 ft from a new sand in the Atoka formation. This well extended the field about 3 miles to the northwest and across a fault which cuts the Cecil anticline in a northeast-southwest direction. This is the largest gas well discovered in Northwest Arkansas.

The Arkansas-Louisiana Gas Company, Sarah Ann Tankersley No. 1, 330 ft N and E C 26-9N-29W, extended the field over a mile to the southwest of the Morris well. This was also a large gas well making initially 74,000,000 cu ft per day through perforations 3516-40 ft; 3610-56 ft; 3714-38 ft and 3806-28 ft, in the Atoka formation and 1,400,000 cu ft per day through perforations 4595-4630 ft and 4654-82 ft in the Hale formation.

The Arkansas-Louisiana Gas Company, Lila Burcham No. 1, 150 ft N 250 ft E C SEc 30-9N-28W, was a dual completion, producing initially 2,300,000 cu ft per day through perforations 4516-4607 ft in the Hale formation and 5,800,000 cu ft per day through perforations 1781-1808 ft from the "Morris" sand of the Atoka formation.

The Arkansas-Louisiana Gas Company, Thos. E. Johnson No. 1, 150 ft S and W C 20-9N-28W, was a dual completion, producing initially 1,500,000 cu ft per day through perforations 4185-4240 ft in the Hale formation, and 500,000 cu ft per day through perforations 3270-3330 ft in the Atoka formation.

The Arkansas-Louisiana Gas Company, Charles G. Andrews No. 1, 600 ft S C 23-9N-28W was dry and abandoned at a total depth of 5540 ft. This dry hole apparently limits the field in a northeast direction.

**Lone Elm Field** (Franklin County)

The Lone Elm field, discovered in 1950, was extended to the south by two completions and to the east by a third. It was limited to the southwest by a dry hole.

The Arkansas Western Gas Company, H. T. Bohannon No. 1, 460 ft N and W C 22-10N-28W, extended the field a mile south of the discovery well. It produced initially 14,000,000 cu ft per day through perforations 2906-34 ft in the Atoka formation.

The Arkansas Western Gas Company, J. L. Stockton Estate No. 1, 600 ft N 260 ft E C 21-10N-28W, a dual completion, extended the field about a mile to the southeast. It produced initially 5,000,000 cu ft per day through perforations 3316-46 ft in the Atoka formation, and 18,000,000 cu ft per day through perforations 2435-90 ft in the Atoka formation.

The Arkansas Western Gas Company, R. S. Lessley No. 1, 1120 ft N and W C 14-10N-28W, extended the

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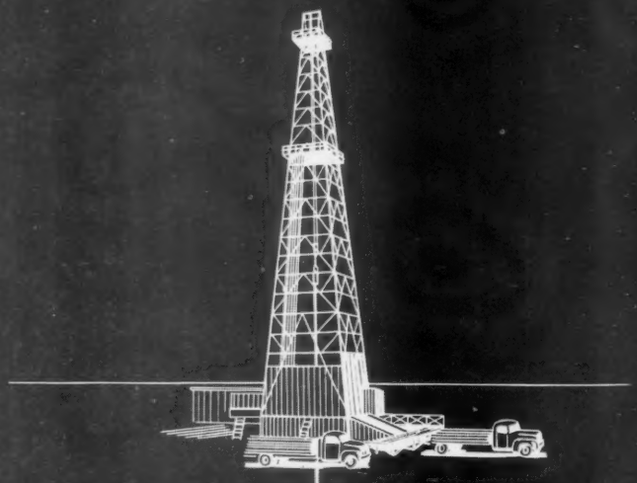

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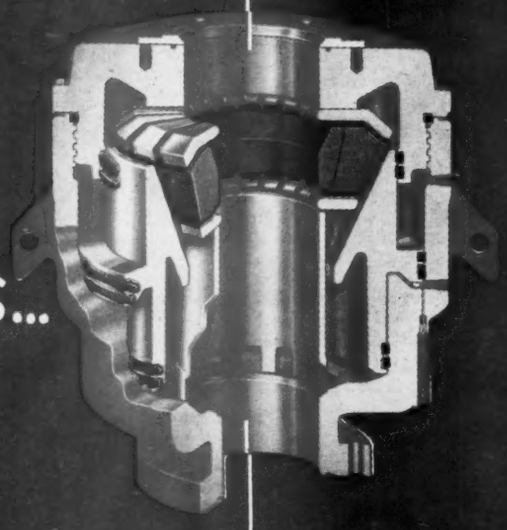

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**CRATER ON FIRE**—Discovery well, Smackover field, largest field so far in Arkansas. "Anderson well"—Oil Operators Trust-Murphy No. 1, sec. 8, T. 16 S., R. 15 W., Union County. Well blew in with only surface casing and formed crater about 450 ft in diameter and over 50 ft deep with rig, boiler, and part of drillstem in crater.

field about a mile to the east. It was a dual completion and made initially 1,000,000 cu ft per day through perforations 2730-64 ft and 6,000,000 cu ft per day through perforations 2905-3018 ft, both in Atoka formation.

The Arkansas Western Gas Company, Sallie Hampton No. 1, 100 ft N 500 ft E C 20-10N-28W, was temporarily abandoned at 3897 ft. It apparently limits the field to the southwest.

**White Oak Field** (Franklin County).

The White Oak field, discovered in 1943, is located on a faulted anticline trending northeast-southwest, and produces from several horizons of the Atoka formation of Pennsylvanian Age. Two producers were completed in the field during the year.

The Arkansas Western Gas Company, Davis No. 1, 1320 ft S 660 ft E NWc 18-10N-26W, a dual completion, came in through perforations 3154-77 ft with an initial production of 6,000,000 cu ft per day and through perforations 2996-3024 ft with an initial production of 11,000,000 cu ft per day, a total of 17,000,000 cu ft per day. This well extended the field about three-fourths of a mile northeast.

The Arkansas Western Gas Company, Henrietta Muncy No. 1, 1650 ft W 930 ft S NEc 25-10N-27W, came in through perforations 3220-68 ft with an initial production of 25,000,000 cu ft per day. This well extended the field about a mile to the southeast.

**Mansfield Field** (Scott County).

The Mansfield gas field, one of the oldest in Arkansas, was discovered in 1902. It is situated on a dome of the Hartford anticline. The Residue Company, Mansfield Gas Company No. 1, 1700 ft S 1500 ft E NWc 6-4N-30W, well situated on the dome, was dry and abandoned at a total depth of 8675 ft in the Jackfork sandstone.

**Massard Prairie Field** (Sebastian).

The Massard Prairie gas field, one of the oldest gas fields in Arkansas, was discovered in 1904. It lies on a faulted northeast-southwest anticline. This field has but one well drilled, the Arkansas-Oklahoma Gas Company, Walter Ayers No. 1, 630 ft S 1200 ft E NWc 11-7N-32W. This well was dry and abandoned at a total depth of 5474 ft in the Morrow group of the Pennsylvanian Age.

## New Fields in 1953

There was only one wildcat well that resulted in tthe discovery of a new gas field in 1953, up to August.

**West Fork Field** (Washington).

This shallow dry gas field was discovered by the Arkansas Western Gas Company, T. S. Threlkeld, Sr., No. 1, situated 1425 ft E 935 ft N C 5-14N-30W. The well was drilled to 586 ft, 5½-in. casing set at 566 ft and the well produced from open hole 566-86 ft in the Sylamore sand of the Devonian. The well, completed January 22, 1953, was not tested until June and made initially 1,500,000 cu ft of dry gas, shut-in pressure 158 lb and bottom hole pressure 160 lb. Another gas well was completed in April about ¾-mile northeast and a dry hole completed in February about a mile northwest of the discovery well. Two outpost wells about three and five miles north were dry. The two gas wells supply the nearby town of West Fork with gas.

## Future Outlook for Arkansas

The lease play, which began in Haskell County, Oklahoma, in 1951 and extended into Arkansas, was continued during 1952 in the Arkansas Valley, and was extended into the Gulf Coastal Plains of East Central Arkansas. An added impetus to this play was the show of gas in the St. Peters sand in the Deep Rock, Sample No. 1 well in 4-10N-6W, White County, completed November 26, 1952. As a result there was a slight increase in drilling in Northwest Arkansas during 1952, and the exploration by geophysical methods and by core holes is still going on. Geophysical work is being conducted by magnetic, gravity and seismograph crews. This exploration will be followed by drilling to test both the Upper Cretaceous and the underlying Paleozoic formations. Continental, Magnolia, Carter, and Gulf Oil Companies are taking a leading part in this exploration.

The Desha Basin in Southeast Arkansas will probably be included in this play. Continental Oil Company is reported planning exploration in this Basin which includes the drilling of test wells in Arkansas County. Geophysical work is being conducted elsewhere in the Basin.

The outstanding development in Northwest Arkansas during 1952 was the three mile westward extension of the Cecil field, and discovery of the prolific shallow gas zone which resulted in the largest gas wells ever brought in in Northwest Arkansas. The first came in making initially 76,500,000 cu ft and the second 75,400,000 cu ft of sweet dry gas.

Exploration for oil in South Arkansas will probably be chiefly concentrated along many of the known faults. The Hibank field in Union County has shown again the possibilities of these faulted areas, as have the other fault fields in this oil producing area of Arkansas.

The new production obtained in the Smackover field and in the East El Dorado area shows the possibilities of additional reservoirs in and around the old fields.

## Acknowledgments

We are pleased to acknowledge assistance received in the preparation of this review from members of the staff of the Arkansas Oil and Gas Commission, namely, Paul M. McLaughlin, director, Jessie Ruth Wood, Eunice Murphy, Irene Bodenhamer, Homer Hughes, J. W. Sanders, G. E. Goodwin, Ralph Dumas, and Paul Horton.

We wish also to express our appreciation for the information obtained through the cooperation of the companies and individuals engaged in the production of oil and gas in Arkansas.

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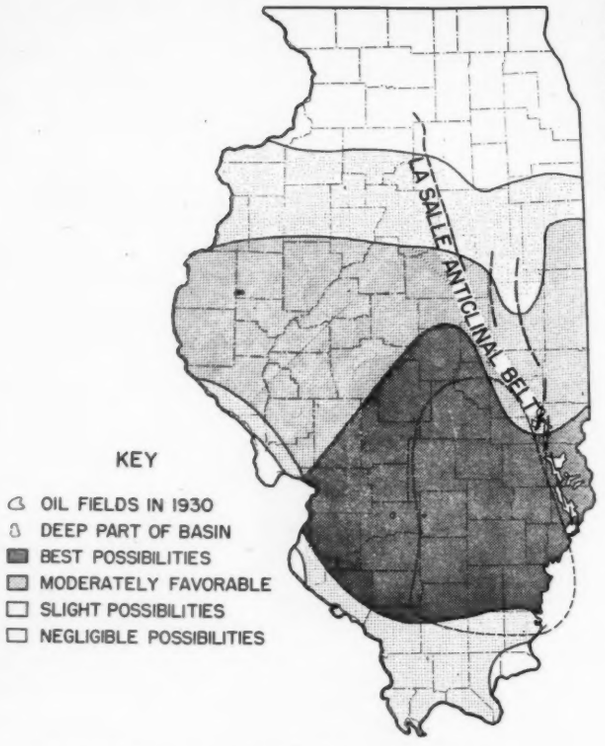


FIG. 1. Oil fields in Illinois and classification of possibilities for future production as of 1930 (after Bell).

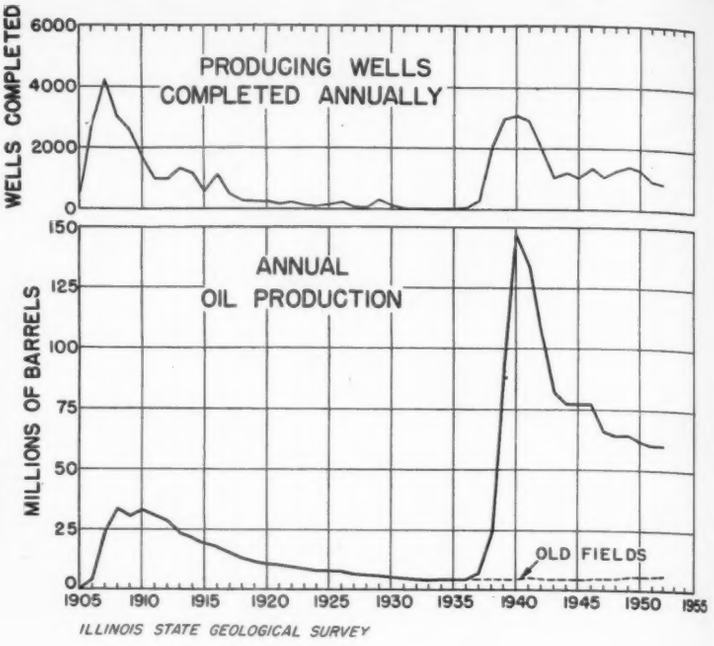


FIG. 2. Annual crude oil production and producing wells completed in Illinois.

# Flooding Can Recover 800 Million Additional Barrels of Oil

*A review of oil production in Illinois indicates an important future for water flooding in the state*

PAUL A. WITHERSPOON

WATER flooding as a means of secondary oil recovery is destined to have widespread effects on oil production in Illinois. At present, less than 10 per cent of the total productive acreage is being flooded, but the successes of the past few years indicate a substantial future for the proper application of this method of oil recovery. In fact, it is conservatively estimated that secondary recovery operations in Illinois will ultimately produce 800,000,000 bbl of oil that would otherwise not be recovered.

Recognizing the opportunities, oil operators in Illinois are developing water floods at a rapid pace. Several recent publications have summarized current flooding operations and include detailed data on individual operations.[1,2] This report reviews the background and discusses a few of the more important features of these operations.

### Primary Oil Production

Significant quantities of oil were first found in 1904 in eastern Illinois near the town of Casey in what is now known as the Westfield pool of Clark County.[3] Subsequent drilling from 1905 to 1911 revealed a series of oil fields trending slightly southeastward from the Westfield pool for a distance of 70 miles along the eastern edge of Illinois (see Fig. 1). Two or more producing zones were found in practically every field at depths ranging from 400 to 2300 ft. The producing formations are predominantly sandstones of Pennsylvanian and Mississippian ages, although one Mississippian limestone, which was named the McClosky "sand," has been a prolific oil producer.

Of the old fields, the Lawrence pool, which was discovered in 1907 in Lawrence County near the south end of the trend, has had the highest oil production, owing no doubt to the presence of five producing horizons. By the end of 1918, the average recovery was 6000 bbl per acre; and by the end of 1952, the recovery was 9300 bbl per acre from 26,800 productive acres, or a total oil production of almost 249,000,000 bbl. This is 50 per cent of all the oil that has been produced in the old fields, although the Lawrence field has only 25 per cent of the productive acreage that was drilled in these early developments.

Early geological studies[3,4] of these oil fields revealed the lenticularity and the unpredictable thickening and thinning of the productive horizons, usually

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**The Author**

Paul A. Witherspoon is head of the petroleum engineering division of the Illinois State Geological Survey, Urbana, Illinois. After graduating from the University of Pittsburgh in 1941, he worked eight and one-half years for Phillips Petroleum Company. Part of this time was spent in chemical process engineering work on the design, construction and initial operation of the Plains butadiene plant at Borger, Texas. The balance of his work with Phillips was on various petroleum production problems, and the last two and one-half years were spent as reservoir engineer in the Eastern Kansas district where he was in charge of all reservoir engineering in connection with Phillips' extensive water flooding operations in Greenwood County, Kansas. In 1949, he entered the University of Kansas and received an MS degree is petroleum engineering physics. He accepted his present position with the Illinois State Geological Survey in 1951.

irregular domes of varying extent. Field development was limited either by edgewater or by a sand pinching out into shale. Water was also reported[4] within the productive limits of many fields beneath the oil zones.

The major structural features were found to coincide with a series of anticlines that has become generally known as the LaSalle anticlinal belt. The relation of this regional trend of anticlines to the position of the oil fields is shown in Fig. 1. The LaSalle anticlinal belt is a series of *en echelon* folds and cross folds forming a steep-sided boundary on the eastern edge of the Illinois basin. A general outline of the deep part of the basin is included on Fig. 1.

During the early drilling, only salt water was encountered whenever test wells were located outside the oil fields on the steep western flanks of the LaSalle anticlinal belt. This knowledge plus the lack of detailed structural data on the Illinois basin led many to believe that the basin was probably a flat-bottomed geosyncline without structural oil traps. Consequently, further prospecting for oil was carried on largely in the shallower beds on the outskirts of the basin. The success of such ventures is shown on Fig. 1 by the limited number of small pools that had been found in western Illinois by 1930.

After oil was discovered on local anticlines in the deeper parts of major structural basins in Michigan and West Texas, Bell suggested in May 1930 that "production similarly located with respect to structure should be looked

**TABLE 1. WATER FLOOD OPERATION IN ILLINOIS DURING 1952.**

| Map No. (1) | Field | Project | Producing formation (2) | Average depth | Operator | Date begun |
|---|---|---|---|---|---|---|
| 1 | Aden Consolidated | Aden | Aux Vases | (S) 3200 | Texas | 8-46 |
| 2 | Aden Consolidated | Aden | McClosky | (L) 3350 | Texas | 8-46 |
| 3 | Albion Consolidated | Albion | L. Bridgeport | (S) 1900 | Carter | 12-47 |
| 4 | Albion Consolidated | ..... | Cypress | (S) 2850 | Concho | 10-52 |
| 5 | Albion Consolidated | ..... | Tar Springs | (S) 2460 | Concho | 10-52 |
| 6 | Albion Consolidated | Stafford | McClosky | (L) 3222 | Continental | 5-43 |
| 7 | Albion Consolidated | Brown Lse | Aux Vases | (S) 3005 | F. Natl. Pet. | 4-52 |
| 8 | Albion Consolidated | ..... | McClosky | (L) 3150 | Jarvis Bros. | 7-51 |
| 9 | Albion Consolidated | South Albion | Bridgeport | (S) 1900 | Superior | 8-46 |
| 10 | Albion Consolidated | Biehl Unit #1 | Biehl | (S) 2000 | Yingling | 8-49 |
| 11 | Albion Consolidated | Biehl Unit #2 | Biehl | (S) 1950 | Yingling | 12-50 |
| 12 | Allendale | Mattaliano | Biehl | (S) 1385 | Luecking | 6-52 |
| 13 | Allison-Weger | Weger | Robinson | (S) 900 | Skiles | 11-52 |
| 14 | Assumption N. | Benoist | Benoist | (S) 1050 | Continental | 7-50 |
| 15 | Barnhill | Barnhill | McClosky | (L) 3350 | Ashland | 1-51 |
| 16 | Barnhill | Walter | McClosky | (L) 3450 | Wayne Dev. | 12-50 |
| 17 | Bartelso | ..... | Cypress | (S) 971 | Kerwin | 4-52 |
| 18 | Bellair | Bellair | Bellair "500" | (S) 550 | Forest | 7-48 |
| 19 | Bellair | Fulton | Bellair "500" | (S) 560 | Pure | 7-48 |
| 20 | Benton | Benton Unit | Tar Springs | (S) 2100 | Shell | 11-49 |
| 21 | Berryville Consolidated | Tarpley | McClosky | (L) 2890 | Phillips | 9-52 |
| 22 | Berryville Consolidated | Townsend | McClosky | (L) 2890 | Phillips | 2-52 |
| 23 | Birds | Highsmith | Robinson | (S) 950 | Franchot | 6-51 |
| 24 | Birds | Birds Area | Robinson | (S) 950 | Tide Water | 2-52 |
| 25 | Birds | Lindsay | Robinson | (S) 960 | Yingling | 8-50 |
| 26 | Browns East | Bellmont | Cypress | (S) 2570 | Magnolia | 11-47 |
| 27 | Browns East | Bell. W. F. Assoc. | Cypress | (S) 2570 | Magnolia | 1-51 |
| 28 | Bungay Consolidated | Blairsville | Aux Vases | (S) 3330 | Texas | 6-48 |
| 29 | Calhoun Consolidated | Calhoun | McClosky | (L) 3150 | Ashland | 9-51 |
| 30 | Calhoun Consolidated | Bohlander | McClosky | (L) 3130 | Phillips | 6-50 |
| 31 | Casey | Casey | Casey | (S) 450 | Forest | 3-50 |
| 32 | Centerville E. | E. Centerville | Tar Springs | (S) 2530 | Sun | 10-50 |
| 33 | Centralia | Copple Trenton | Trenton | (L) 3950 | Sohio | 11-51 |
| 34 | Clay City Consolidated | M. Lambrich Unit | McClosky | (L) 3060 | F & W Oil | 8-50 |
| 35 | Concord | Tuley | McClosky | (L) 2960 | Phillips | 7-51 |
| 36 | Cordes | Cordes | Benoist | (S) 1230 | Shell | 8-50 |
| 37 | Dale Consolidated | N. Rural Hill U. | Aux Vases | (S) 3125 | Inland | 2-52 |
| 38 | Dale Consolidated | W. Dale Unit | Aux Vases | (S) 3050 | Texas | 8-51 |
| 39 | Friendsville N. | Litherland | Biehl | (S) 1620 | Magnolia | 7-47 |
| 40 | Golden Gate Consolidated | W. F. Unit | St. Gen. | (L) 3260 | Cities Ser. | 11-52 |
| 41 | Iron | Iron Unit | Hardinsburg | (S) 2500 | Shell | 12-50 |
| 42 | Johnson N. | Block A | Casey | (S) 450 | McMahon | 4-49 |
| 43 | Johnson N. | Block B | 500-ft. | (S) 480 | McMahon | 5-51 |
| 44 | Johnson N. | V. Jones | Casey | (S) 440 | Sherrill | 9-51 |
| 45 | Johnson N. | Clark Co. #1 | Casey | (S) 425 | Tide Water | 2-50 |
| 46 | Johnson S. | S. Johnson | U. Partlow | (S) 490 | Forest | 3-49 |
| 47 | Junction | ..... | Waltersburg | (S) 1750 | Lewis | 5-51 |
| 48 | Kenner W. | W. Kenner Unit | Cypress | (S) 2600 | Phillips | 2-52 |
| 49 | Lawrence | Klondike | Benoist | (S) 1625 | Geo. & Wrather | 6-52 |
| 50 | Lawrence | ..... | Bridgeport | (S) .... | Ohio | ..... |
| 51 | Lawrence | ..... | Bridgeport | (S) .... | Ohio | ..... |
| 52 | Lawrence | ..... | Kirkwood | (S) .... | Ohio | 1-52 |
| 53 | Lawrence | ..... | Kirkwood | (S) .... | Ohio | 1-52 |
| 54 | Loudon | Loudon | Chester | (S) 1500 | Carter | 10-50 |
| 55 | Main | N. Morris | Robinson | (S) 983 | Ark. Fuel | 4-51 |
| 56 | Main | J. S. Kirk | Robinson | (S) 913 | Buckeye | 8-51 |
| 57 | Main | Sanders | Penna. | (S) 850 | Constantin | 8-52 |
| 58 | Main | Short | Penna. | (S) 850 | Constantin | 2-52 |
| 59 | Main | Wood | Penna. | (S) 850 | Constantin | 8-52 |
| 60 | Main | Stanfield | Robinson | (S) 977 | Leverton | 5-52 |
| 61 | Main | A. Reynolds | Robinson | (S) 940 | Logan | 12-51 |
| 62 | Main | ..... | Robinson | (S)..... | Ohio | ..... |
| 63 | Main | ..... | Robinson | (S) .... | Ohio | ..... |
| 64 | Main | ..... | Robinson | (S) .... | Ohio | ..... |
| 65 | Main | ..... | Robinson | (S) 1000 | Pet. Prod. | 8-51 |
| 66 | Main | Hughes Rob. | Robinson | (S) 850 | Pickens | 6-51 |
| 67 | Main | Dennis-Lloyd | Robinson | (S) 1035 | Skiles | 7-51 |
| 68 | Main | Highsmith | Robinson | (S) 830 | Skiles | 9-51 |
| 69 | Main | Walter Com. | Robinson | (S) 950 | Skiles | 12-51 |
| 70 | Main | Clarke-Hulse | Robinson | (S) 910 | Tide Water | 1-52 |
| 71 | Main | Dennis-Hardin | Robinson | (S) 875 | Tide Water | 8-50 |
| 72 | Main | Henry-Irkemire | Robinson | (S) 935 | Tide Water | 2-48 |
| 73 | Main | W. A. Howard | Robinson | (S) 950 | Tide Water | 12-52 |
| 74 | Main | Stifle-Drake | Robinson | (S) 980 | Tide Water | 6-52 |
| 75 | Main | G. L. Thompson | Robinson | (S) 860 | Tide Water | 9-52 |
| 76 | Main | Hughes-Walker | Robinson | (S) 880 | Wilson | 8-50 |
| 77 | Martinsville | ..... | Carper | (S) 1346 | Buchman | 10-52 |
| 78 | Martinsville | Carper | Carper | (S) 1334 | Magnolia | 1-51 |
| 79 | Martinsville | Casey | Casey | (S) 464 | Magnolia | 8-50 |
| 80 | Mattoon | Mattoon | Cypress & Rosiclare | (S) 1750<br>(S) 1950 | Carter | 5-52 |
| 81 | Mattoon | Mattoon | Rosiclare | (S) 1952 | Phillips | 11-50 |
| 82 | Maunie S. | Tar Spr. Unit | Tar Springs | (S) 2270 | Magnolia | 8-47 |
| 83 | Maunie S. | Tar Spr. Unit #2 | Tar Springs | (S) 2275 | Magnolia | 11-49 |
| 84 | Mill Shoals | B. R. Gray | Aux Vases | (S) 3245 | Sohio | 5-52 |
| 85 | Mt. Carmel | G. Dunkel | Biehl | (S) 1500 | Engel | 6-52 |
| 86 | Mt. Carmel | S. Courter | Biehl | (S) 1375 | F. Natl. Pet. | 2-50 |
| 87 | Mt. Carmel | N. Mt. Carmel | Biehl | (S) 1500 | Superior | 6-49 |
| 88 | Mt. Carmel | Stein | Tar Springs | (S) 2040 | Texas | 2-52 |
| 89 | New Harmony Cons. | Helm | Aux Vases | (S) 2750 | Luboil | 12-51 |
| 90 | New Harmony Cons. | Helm | Benoist | (S) 2640 | Luboil | 12-51 |
| 91 | New Harmony Cons. | Helm | Waltersburg | (S) 2115 | Luboil | 12-50 |
| 92 | New Harmony Cons. | Schultz | U. Cypress | (S) 2500 | Phillips | 5-52 |

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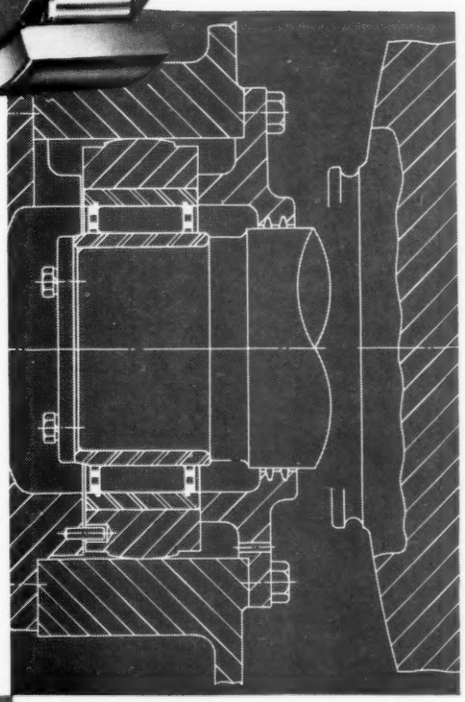

**Check the drawing at the left. The bearing is a Hyatt Hy-Load, and because the inner race is cylindrical, the shaft it supports is free to move axially—thus allowing for shaft expansion without cramping the bearing or distorting the shaft. Obviously, this is only one of many ways in which Hyatt bearings can be used to reduce costs as they reduce friction, but it's a good example of why so many designers throughout industry keep their Hyatt catalogs within easy reach.**

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# HYATT ROLLER BEARINGS

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for in Illinois."[5] Later in the same year Bell presented a map classifying the state into areas according to the relative probabilities of finding new oil fields. His areal classifications are included in Fig. 1.

During the 1930's, the exploration for oil was slowly intensified, but only one new field had been found by 1936. In 1937, however, the discovery of 10 new oil fields in the Illinois basin marked the beginning of a second oil boom that lasted several years. Many are familiar with this period of rapid development, high initial production, and lack of proration. Fig. 2 shows the state's yearly oil production since 1905 and the producing wells completed annually, excluding dry holes. The high productivity of the large number of wells completed in the second boom is reflected in the abrupt increase in oil production from 4,000,000 bbl in 1936 to 148,000,000 bbl in 1940. As a result, Illinois was raised from the fourteenth largest oil-producing state to the fourth largest in a period of four years.

As in the old fields, multiple producing zones were found in many of the new pools at depths ranging from 1000 to 4500 ft. The "pay" zones are practically all limestones and sandstones of Mississippian age. A few Pennsylvanian sands are productive, as are limestones of Silurian, Devonian, and Ordovician ages. The Salem field, which was discovered in 1938 and has three sand and four lime horizons, is undoubtedly the most prolific pool of appreciable size in Illinois. At the end of 1952, this field had produced 222,000,000 bbl of oil from 9500 productive acres, or an overall average of 23,400 bbl per acre.

Prospecting for oil in the Illinois basin has been highly successful. By the end of 1952, the accumulated oil production for the state was 1629 million barrels from 425,000 acres. Of this volume, 507,000,000 bbl have been recovered from 114,000 acres in the old fields, and 1122 million barrels have been recovered from 311,000 acres in the new fields drilled since January 1, 1937. Discoveries of new fields and extensions to existing pools have continued each year since 1937. Location of all oil fields of significant size in Illinois as of January 1, 1953, is shown on Fig. 3. Bell's selection of the area with the best oil possibilities, as discussed in connection with Fig. 1, is repeated on the index map of Fig. 3. It is interesting to observe that Bell's choice in 1930 of the area with the best possibilities for future production comes remarkably close to the area that has been so intensively developed since 1937.

### Vacuum and Repressuring

The first attempts to improve oil recoveries by use of vacuum were started in 1910 in the Clark County fields,[6] and by 1920 vacuum was being widely used in all of the old fields. Air and gas repressuring usually followed the vacuum operations because the equipment for the latter was easily adaptable to the needs of repressuring. Injection of air and gas was first begun in 1921 and was being extensively used in the old fields of Clark and Crawford counties by 1932.[7]

After the new fields were discovered in 1937, large volumes of gas were available in some places, and extensive gas repressuring operations were begun in a number of new fields. Meanwhile, air and gas repressuring operations were continually being expanded in the old fields. As of January 1, 1947, it was reported[8] that a total of 18,000 acres was being repressured in Illinois, or five per cent of the oil productive acreage in the state. Many of these projects are still operating today although there is a definite trend toward conversion to water flooding. On the basis of the few reports that have been published on air and gas repressuring,[7,8] it is estimated that the total oil recovery by these methods is currently of the order of 10,000,000 bbl, or less than one per cent of the state's cumulative oil production.

### Water Flooding

Early investigators[9] recognized the fact that unusual oil recoveries were being obtained in certain parts of the old fields because of water invasion. Squires and Bell made a series of investigations of these conditions from 1931 to 1937 and have summarized their findings in a comprehensive report.[10] They identified 11 "natural" floods and 27 small accidental floods scattered over various parts of the old fields. Some abnormally high oil recoveries were found where a natural water movement was active in the McClosky "sands" of the Lawrence field. This will partially explain the high oil recovery that has been obtained in this field. The accidental floods in other fields were attributed to upper waters invading the oil sands through old plugged holes or casing leaks. Squires and Bell report that at the time of their investigations more than 412,000 bbl of oil had been recovered in the old fields

**TABLE 1—Continued**

| Map No. (1) | Filed | Project | Producing formation (2) | | Average depth | Operator | Date begun |
|---|---|---|---|---|---|---|---|
| 93 | New Harmony Cons. | Schultz | L. Cypress | (S) | 2500 | Phillips | 7-51 |
| 94 | New Harmony Cons. | E. Maud | Benoist | (S) | 2520 | Skiles | 4-52 |
| 95 | New Harmony Cons. | E. Maud | Cypress | (S) | 2400 | Skiles | 11-52 |
| 96 | New Harmony Cons. | S. Bottoms | Benoist | (S) | 2680 | Skiles | 10-51 |
| 97 | New Harmony Cons. | W. Maud | Benoist | (S) | 2620 | Skiles | 10-50 |
| 98 | New Harmony Cons. | Ford "A" | McClosky | (L) | 2900 | Sun | 5-49 |
| 99 | New Harmony Cons. | Greathouse | Bethel | (S) | 2750 | Sun | 1-49 |
| 100 | New Harmony Cons. | Greathouse | McClosky | (L) | 2900 | Sun | 8-47 |
| 101 | New Narmony Cons. | Waltersburg | Waltersburg | (S) | 2200 | Superior | 8-46 |
| 102 | New Harmony Cons. | Dennis "A" | Bethel | (S) | 2700 | Tide Water | 7-51 |
| 103 | New Harmony Cons. | O. R. Evans | Aux Vases | (S) | 2800 | Tide Water | 10-49 |
| 104 | Odin | Odin | Cypress | (S) | 1700 | Ashland | 10-49 |
| 105 | Olney Consld. | Olney E. | McClosky | (L) | 3100 | Texas | 3-51 |
| 106 | Patoka | Benoist | Benoist | (S) | 1410 | Sohio | 9-43 |
| 107 | Patoka | Rosiclare | Rosiclare | (S) | 1550 | Sohio | 48 |
| 108 | Patoka | Stein Unit | Stein | (S) | 1280 | Sohio | 8-51 |
| 109 | Phillipstown Cons. | Unit "A" | Penna. | (S) | 1912 | Brehm | 6-52 |
| 110 | Phillipstown Cons. | N. Calvin | Penna. | (S) | 1550 | Brit-Amer. | 6-51 |
| 111 | Phillipstown Cons. | S. Seifried | Biehl | (S) | 1830 | Magnolia | 5-51 |
| 112 | Phillipstown Cons. | Laura | Benoist | (S) | 2800 | Phillips | 3-52 |
| 113 | St. Marie | St. Marie | McClosky | (L) | 2860 | Lebow | 10-48 |
| 114 | Salem | Salem Unit | Benoist | (S) | 1770 | Texas | 10-50 |
| 115 | Salem | Salem Unit | Renault & Aux Vases | (S) | 1825 | Texas | 10-50 |
| 116 | Salem | Salem Unit | McClosky | (L) | 1950 | Texas | 4-51 |
| 117 | Salem | Salem Unit | Devonian | (L) | 3400 | Texas | 10-50 |
| 118 | Salem | Rosiclare Unit | Rosiclare | (S) | 2093 | Texas | 4-50 |
| 119 | Siggins | Flood "1" | U. Siggins | (S) | 320 | Bell Bros. | 9-50 |
| 120 | Siggins | Vevay Park | Siggins | (S) | 600 | L. Fikes | 12-50 |
| 121 | Siggins | Siggins | Siggins | (S) | 400 | Forest | 6-42 |
| 122 | Siggins | Siggins | Casey | (S) | 447 | Hamd. & Whel. | 12-51 |
| 123 | Siggins | Union Gr. | Siggins | (S) | 404 | Pure | 12-46 |
| 124 | Storms | ..... | Waltersburg | (S) | 2241 | Mabee | 7-51 |
| 125 | Westfield | Hawkins | Gas Sand | (S) | .... | Constantin | 8-51 |
| 126 | Westfield | Johnson | Gas Sand | (S) | .... | Constantin | 6-51 |
| 127 | Westheld | Parker | Gas Sand | (S) | 270 | Forest | 6-40 |
| 128 | Willow Hill E. | ..... | McClosky | (L) | 2615 | Spickler | 6-52 |
| 129 | Woburn | Spindler | Benoist | (S) | 1006 | Arrow Drlg. | 9-51 |
| 130 | York | York | Casey | (S) | 590 | Trans-South. | 10-50 |
| 131 | Lawrence | Applegate | Jackson | (S) | 1320 | Sherrill | 9-52 |
| 132 | Albion Consolidated | S. Albion (3) | Biehl | (S) | 2080 | Calvert | 4-51 |
| 133 | Bone Gap Consolidated | .....(3) | Waltersburg | (S) | 2310 | Gallagher | 6-52 |
| 134 | Boyd | Boyd Rep. (3) | Bethel | (S) | 2065 | Superior | 6-45 |
| 135 | Dix | Dix (3) | Bethel | (S) | 1950 | Carter | 1-48 |
| 136 | Loudon | Loudon Dev. (3) | Devonian | (L) | 3100 | Carter | 9-43 |
| 137 | Omaha | Omaha (3) | Palestine | (S) | 1700 | Carter | 10-44 |

Note: (1) Refers to numbers shown on Fig. 7
(2) (S) - sand, (L) - lime
(3) Pressure maintenance operation

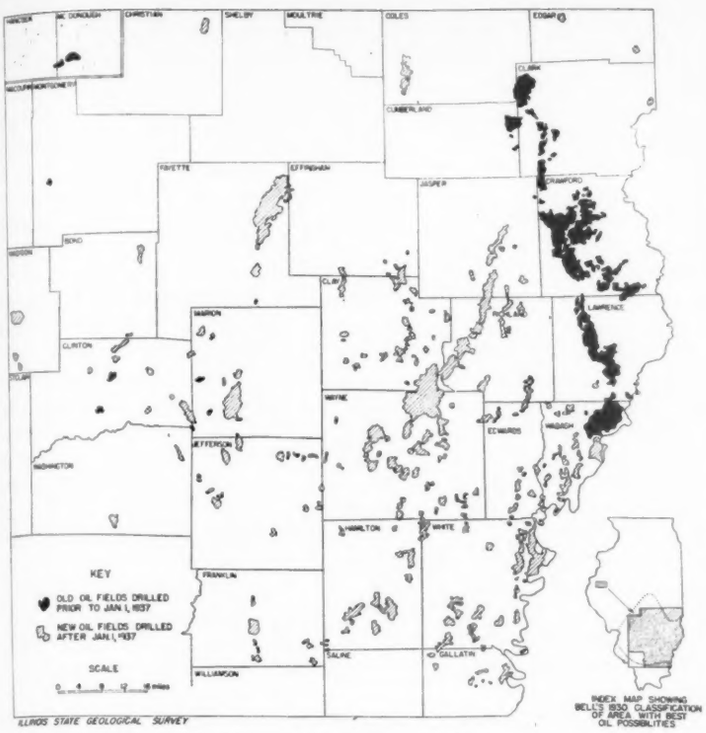
KEY
OLD OIL FIELDS DRILLED PRIOR TO JAN 1, 1937
NEW OIL FIELDS DRILLED AFTER JAN 1, 1937
SCALE
INDEX MAP SHOWING BELLS (B30 CLASSIFICATION OF AREA WITH BEST OIL POSSIBILITIES
ILLINOIS STATE GEOLOGICAL SURVEY

**FIG. 3. Illinois oil fields as of January 1, 1953.**

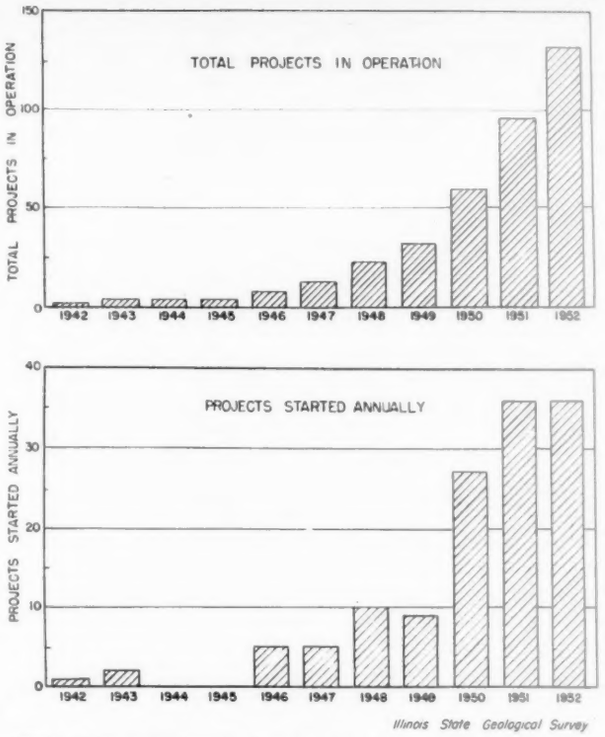
TOTAL PROJECTS IN OPERATION
TOTAL PROJECTS IN OPERATION
PROJECTS STARTED ANNUALLY
PROJECTS STARTED ANNUALLY
1942 1943 1944 1945 1946 1947 1948 1949 1950 1951 1952
Illinois State Geological Survey

**FIG. 5. Development of water flood projects in Illinois.**

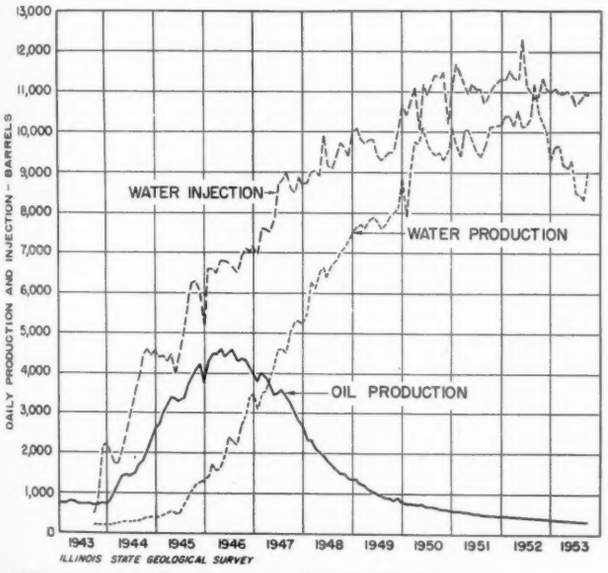
WATER INJECTION
WATER PRODUCTION
OIL PRODUCTION
DAILY PRODUCTION AND INJECTION - BARRELS
1943 1944 1945 1946 1947 1948 1949 1950 1951 1952 1953
ILLINOIS STATE GEOLOGICAL SURVEY

**FIG. 4. Patoka Benoist water flood performance, Marion County, Illinois.**

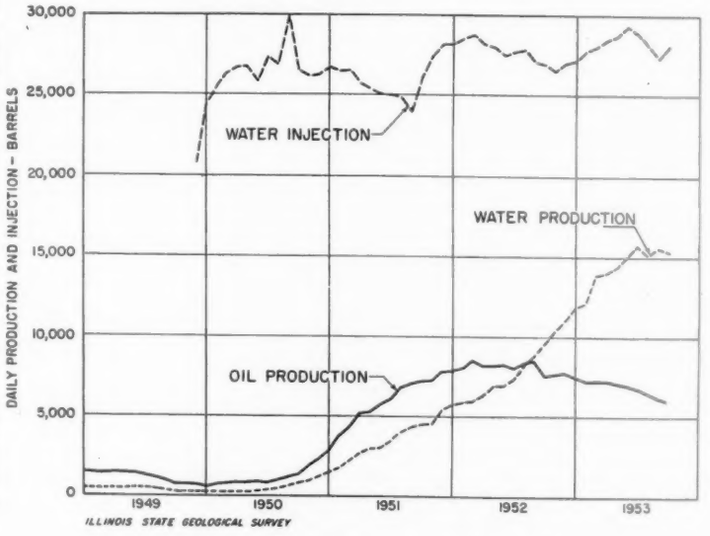


**FIG. 6. Benton Unit water flood performance, Franklin County, Illinois.**

by accidental flooding of 115 acres, or almost 3600 bbl per acre.

One of these accidental floods at the north end of the Main pool in Crawford County was converted into the first intentional water flood in 1924. Only produced water was available, and it was injected into two wells that were no longer economical producers as a result of the previous accidental flood. This operation produced 38,500 bbl of oil from seven acres in nine years, or 5500 bbl per acre.[11]

On June 8, 1933, water flooding was legalized in the state of Illinois, and in August 1933, Tide Water Associated Oil Company began the first legal water injection on its Drake No. 2 lease in the Main pool in Crawford County. Fresh well water and produced salt water were mixed and injected without treatment in one input well. The lease increased from two barrels per day in 1933 to a peak of seven barrels per day in October 1935, and had produced 17,000 bbl of oil, or 1200 bbl per acre, by July 1943.[12] Several other similar one-well floods were begun by various operators in the following years with either no benefit to production or relatively small increases.

In June 1942, the Forest Oil Corporation began the first five-spot pattern flood in Illinois in the Siggins pool in Cumberland County. This project began as a 40-acre pilot flood in the First Siggins sand at a depth of 400 ft. Forest has extended their operations several times and, at the end of 1952, there were 1800 developed acres on 4½-acre spacing (440 ft between like wells). In December 1946 Pure Oil Company began flooding operations on adjoining properties using the same spacing. They have developed 402 acres in the First Siggins sand and 269 acres in the Second Siggins sand at 465 ft. Details of the development and operational procedures of both companies have been described elsewhere.[13] As of January 1, 1953, the combined operations

have recovered 6,174,000 bbl of water flood oil from 2268 developed acres, or 2720 bbl per acre. The accumulated water input is 35,392,000 bbl or a ratio of 5.7 bbl of water injected for each barrel of oil recovered. The ultimate water flood oil recovery will be considerably higher because some of the developments have been made only in the past few years.

In September 1943, the well-known Patoka Benoist water flood was begun in the Patoka field in the northwest corner of Marion County. This project is in the Benoist sand at a depth of 1410 ft. The flood is operated by the Sohio Petroleum Company and covers 527 acres developed on 10-acre spacing (660 ft between like wells). Barger has presented a detailed discussion of all phases of this project.[14]

Fig. 4 summarizes the water flood performance up to October 1953. It is interesting to note that the peak oil production in July 1946 was 4560 bbl per day or almost 70 per cent of the water input rate, which indicates an unusually high degree of efficiency of oil movement. This peak water flood oil production compares with a peak primary production of 2050 bbl per day in January 1938. As of October 1, 1953, the Patoka Benoist water flood had produced 5,960,000 bbl of oil, or 11,300 bbl per acre, compared to a primary recovery of 4950 bbl per acre. The accumulated water input was 30,830,000 bbl or an input water-oil ratio of 5.2:1. Barger has estimated that the ultimate water flood recovery will be 12,100 bbl per acre, or 460 bbl per acre-foot.[14] This unusually high oil recovery is by far the best water flood result that has been obtained from pattern flooding in Illinois.

After the Siggins and Patoka floods were developed and their successes became generally known, Illinois operators began to take more interest in water flooding. As a result, water flood projects have developed more rapidly in the last few years. Fig. 5 shows the number of floods that have been developed each year since 1942 and that are still in operation. The recent interest in water flooding is very evident.

In November 1949, the Shell Oil Company initiated a major water flood operation in their Benton Unit in Franklin County. This project has received much attention because it has been producing the largest volume of water flood oil in the state. Cameron has presented a detailed analysis of the development and initial operation of this project.[15].

Fig. 6 summarizes the water flood performance up to October 1953. The drop in production after July 1949 was the result of converting alternate producing wells to water injection during the period of initial development. The oil production was back to its former level by September 1951, and reached a peak of approximately 8400 bbl per day in August 1952. This compares with 1500 bbl per day prior to flooding. The cumulative water flood recovery to October 1, 1953, was 5,830,000 bbl, or 2650 bbl per acre for the 2200 developed acres. The accumulated water input was 37,820,000 bbl, or an input water-oil ratio of 6.5:1. The ultimate secondary recovery should be 7500 bbl per acre, or 200 bbl per acre-foot.[15]

An unusual feature of the Benton Unit is that the producing horizon at a depth of 2100 ft is completely overlain by an extensive coal mining operation at a depth of 500 ft. In the original drilling on ten-acre spacing, adequate precautions were taken to locate all wells in order that drilling would penetrate mine pillars (about 200 ft square), after which casing strings were set through the coal bed. Further infill drilling was undesirable in developing a water flood, and consequently, a 20-acre spacing pattern (935 ft between like wells) was adopted by converting alternate producing wells to injection. All input wells are equipped with tubing and packers set at the bottom of the production string. The casing annulus is kept filled with treated water under a slight surface pressure so that leakage, as indicated by any pressure changes, may be more easily detected. This is the first pattern flood in Illinois to operate under such unusual conditions to use such wide spacing.

As flooding operations continue to expand, the problem arises concerning the feasibility of simultaneously flooding several stratigraphic horizons in the same field. This problem has recently been accentuated in the Salem field where flooding operations were initiated in three sand and two lime formations out of the seven oil producing zones. Unitization was desirable in this project, and therefore a very careful engineering study was made of the various oil reservoirs prior to the start of injection. Love[16] has presented a detailed analysis of the manner in which the interests of some 2000 royalty owners and 25 companies have been successfully unitized. At present 8800 acres of this field have been set up as the Salem Unit with The Texas Company as operator.

As one might expect, the five producing zones currently being flooded in the Salem Unit do not have the same areal extent, although they overlie one another generally and are all located on

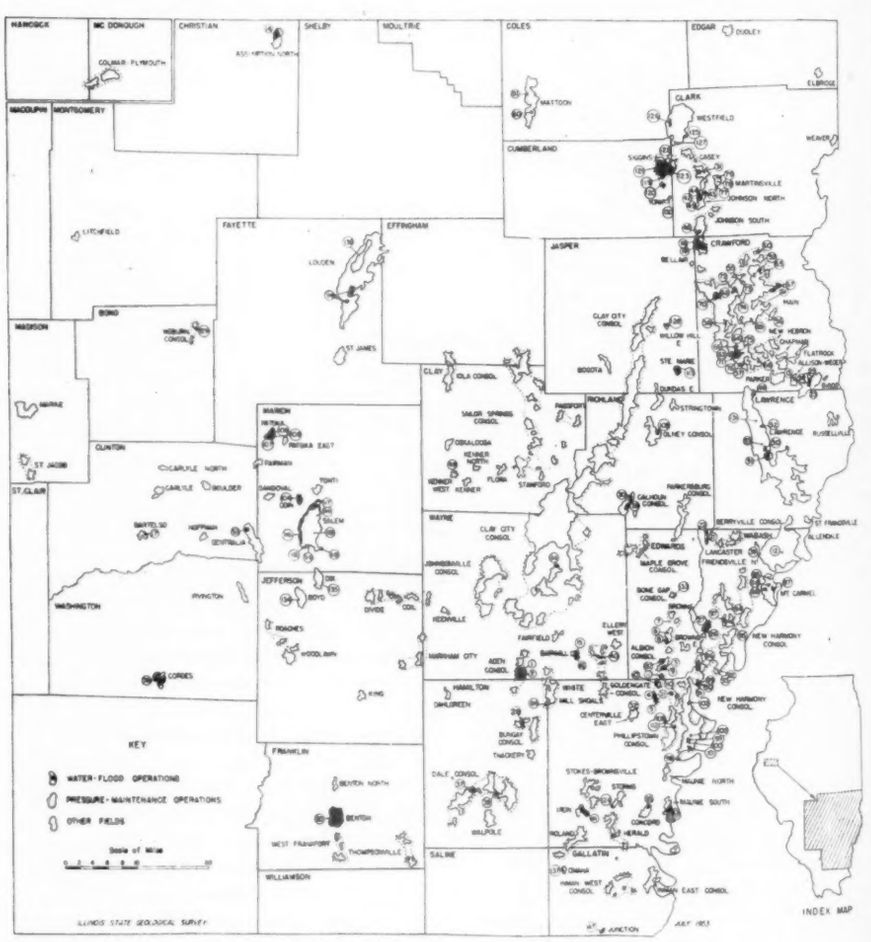


**FIG. 7. Water flood operations in Illinois during 1952.**

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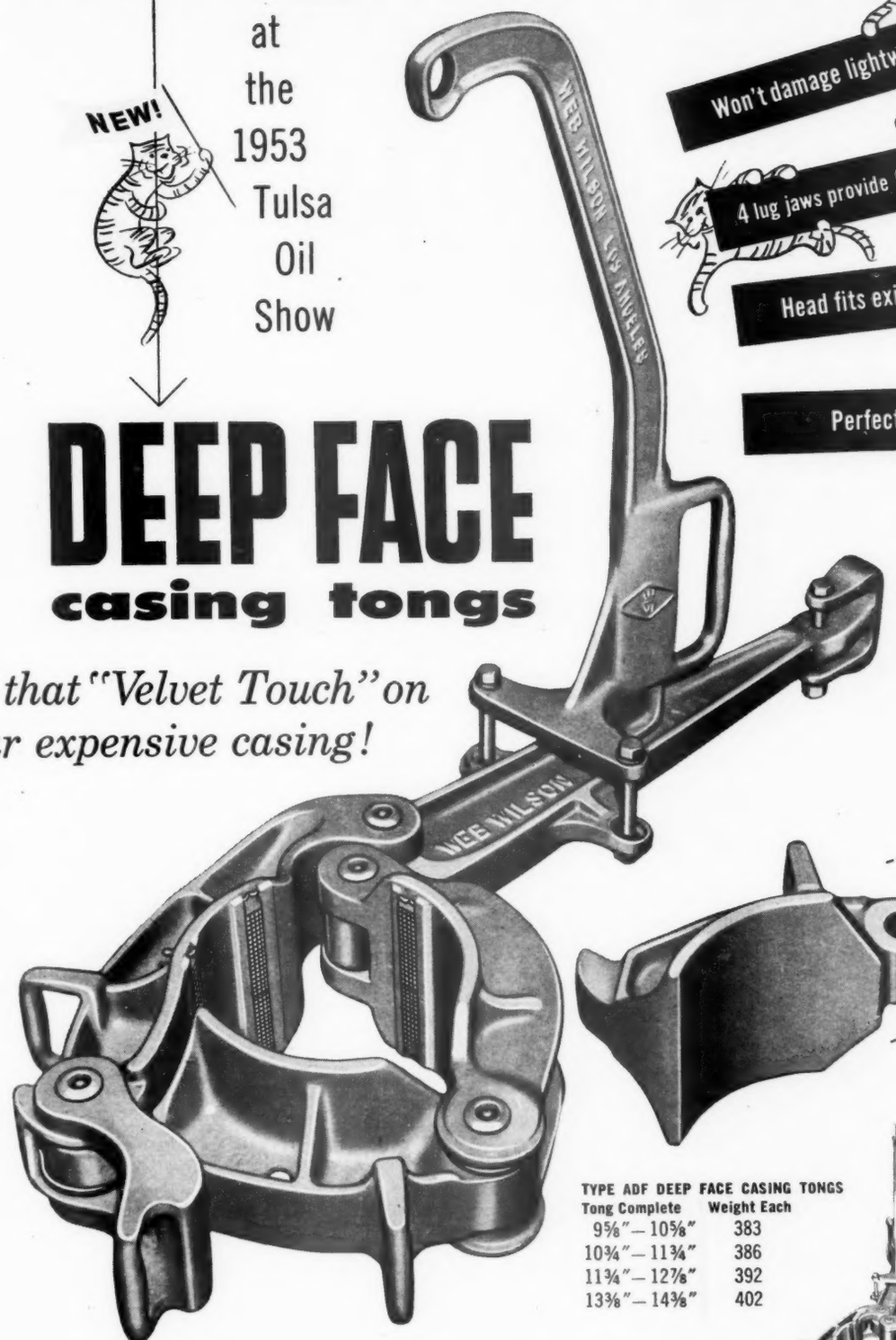


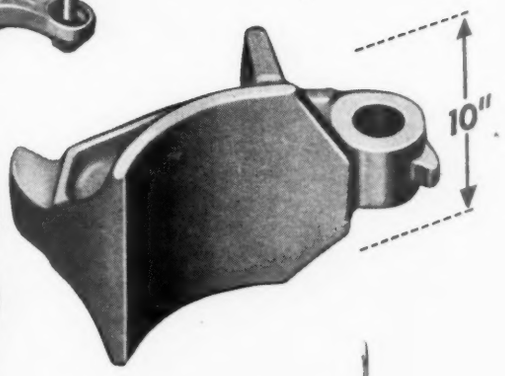


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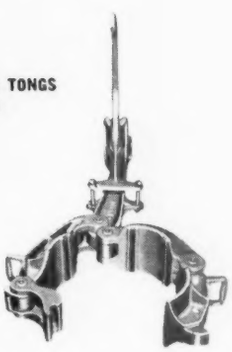
| 10¾"—11¾" | 386 |
| 11¾"—12⅞" | 392 |
| 13⅜"—14⅜" | 402 |



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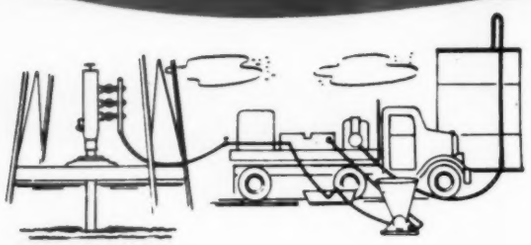

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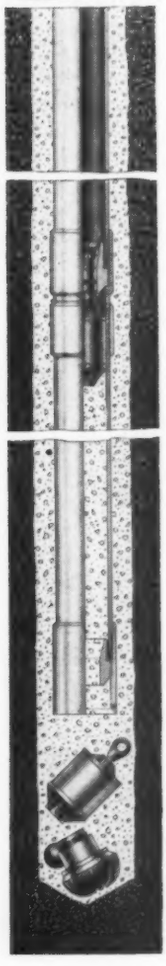

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an elongated asymmetrical anticline having about 200 ft of closure. To flood each one of these zones in succession would prolong the operation unnecessarily, because each reservoir is in itself a major oil field. Engineering studies were therefore directed toward a program of flooding all five oil reservoirs simultaneously.

Livingston[17] has recently presented a thorough discussion of the flooding facilities that have been installed in the Salem Unit. Some ingenious devices have been developed for automatic handling of the enormous volumes of oil and water involved. The magnitude of the problems can perhaps be better appreciated by considering a few general statistics. It is estimated that the water flood reserves in the Salem Unit are approximately 200,000,000 bbl.[16] If it is assumed that the accumulated water input will be 10 times the anticipated oil recovery and that 20 years is an economically desirable flood life, then the maximum injection rates will be of the order of 300,000 bbl per day. This volume of water must be proportioned to each of the flood zones to get a relatively even flood-out. This means selecting the location of injection wells in such a way as to establish the desired flood pattern in each of the productive horizons of varying areal extent. Because permeabilities range from 60 md in the tightest sand to a darcy or more in the limestone formations, well-head injection pressures will vary considerably and are an important factor to consider in designing and operating a common injection system. Water flooding the Salem Unit is relatively complicated, and thus the progress of the project will be followed with interest.

The locations of water floods in operation in Illinois during 1952 are shown on Fig. 7. This map is reproduced from a recent detailed report on water flooding in Illinois.[2] A few general statistics from this report are summarized in Table 1 for use in identifying the numbered projects on Fig. 7. Included on the map are the locations of several pressure maintenance projects which are using water as their injection medium.

In addition to these operations, the "dump" flooding technique has been extensively used in the large Clay City Consolidated field. The word "dump" is used to describe flooding by perforating selected wells at water zones overlying an oil-producing formation. Water flows by gravity into the oil zone usually with very little control. The main reason that "dump" flooding has been successful in the Clay City field is that the principle oil reservoir is the highly permeable, oolitic McClosky limestone (same formation as prolific McClosky "sands" of Lawrence field).

Excluding the "dump" floods in the

Clay City Consolidated field, there were approximately 140 water flood projects in operation in Illinois during 1952, 131 of which are located on Fig. 7. These floods had developed a total of 31,330 acres, by the end of 1952, or 8 per cent of the state's oil-productive acreage. By October 1953, it is estimated there were about 160 water floods in operation in Illinois.

According to the latest report,[2] the cumulative water flood oil recovery at the end of 1952 was approximately 41,000,000 bbl, which includes an estimated 12,000,000 bbl of "dump" flood oil. During the year 1952, a total of 72,951,000 bbl of water was injected in recovering 8,752,000 bbl of water flood oil, or a ratio of 8.3 bbl of water for each barrel of oil. An additional 2,000,000 bbl of oil are estimated to have been recovered by "dump" flooding. Thus, water flooding produced approximately 11,000,000 bbl of oil in 1952, or 18 per cent of the state's total recovery of 60,071,000 bbl.

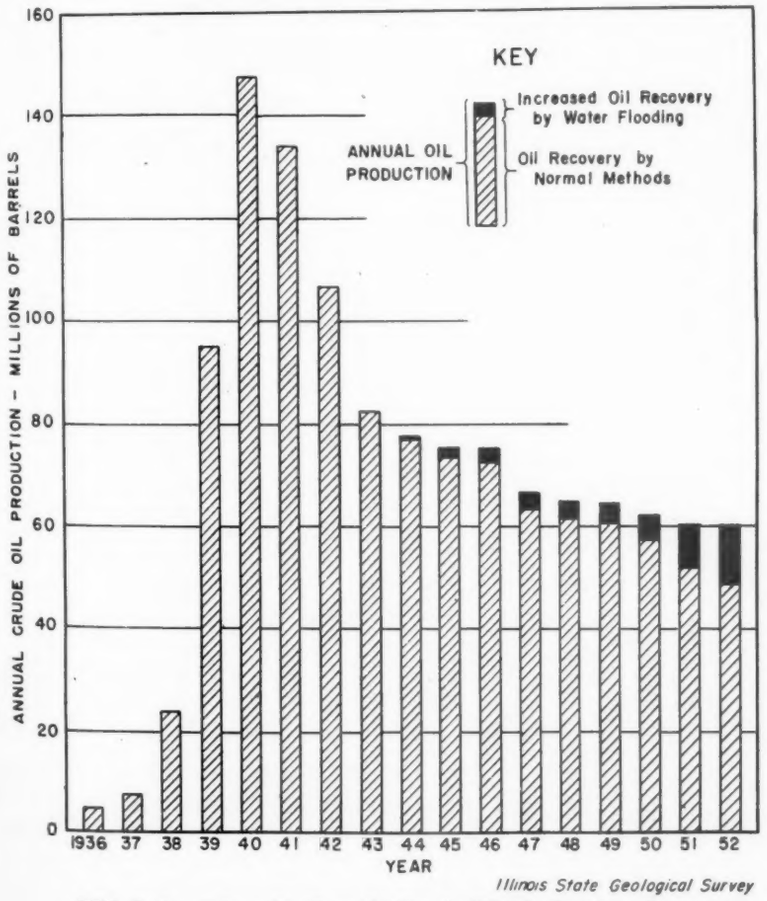
The effect of water flood (including "dump" flood) operations on the state's annual crude oil production since 1936 is shown in Fig. 8. The rate of decline in annual production has noticeably decreased as a result of increasing secondary oil recoveries. In fact, Illinois' annual crude production has remained at approximately 60,000,000 bbl for the past two years largely because of increasing returns from flooding.

### Estimated Secondary Reserves

Past production in both the old and new fields has generally been obtained by the solution-gas drive mechanism. Natural water drives and accidental floods in parts of the old fields have undoubtedly been a minor contributing factor as has the use of vacuum and air and gas repressuring. The oil recovery is probably of the order of 25 per cent of the original stock tank oil in place. Barger and Campbell state that primary recoveries amount to 10 to 25 per cent of stock oil in place.[18] Since the accumulated recovery for the state is approximately 1.6 billion barrels, the volume of oil that still remains in known producing fields is apparently in excess of four billion barrels. With this in mind, a secondary recovery of 800,000,000 bbl is believed to be a conservative estimate. As more water flooding experience is gained under the variety of conditions that exist in Illinois, better estimates of secondary reserves will be possible.

### Acknowledgments

This article was especially prepared for *The Petroleum Engineer* and was




*Illinois State Geological Survey*

**FIG. 8. Annual crude oil production in Illinois showing oil recovery obtained by normal operating methods and increased recovery by water flooding.**

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based on a paper entitled, "Some Important Aspects of Water Flooding in Illinois," which was presented by the author at the spring meeting of the eastern district, Division of Production, American Petroleum Institute, at Pittsburgh, Pennsylvania, April 4, 1952, and was later published as Circular 180 of the Illinois State Geological Survey. The author wishes to express his appreciation to C. R. Temple and the Sohio Petroleum Company for permission to publish the up-to-date graph on the Patoka Benoist water flood (Fig. 4) and to E. A. Davenport and the Shell Oil Company for permission to publish the up-to-date graph on the Benton Unit water flood (Fig. 6). Article published with permission of the Chief, Illinois Geological Survey, Urbana, Illinois.

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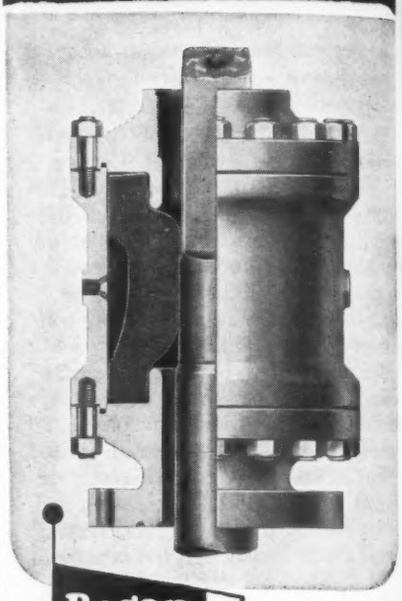

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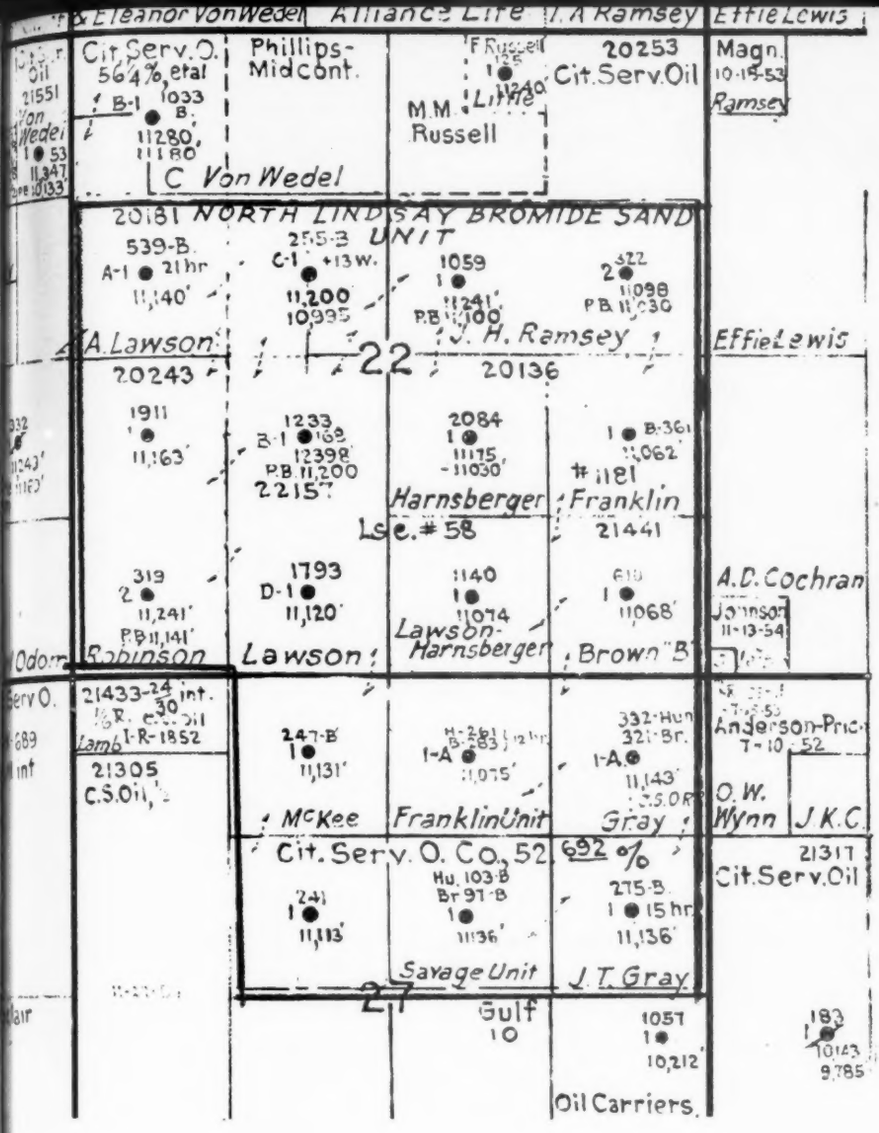


# FLOODING . . . . . .

## Two Miles Down

*Cities Service injects water in Bromide sand at 11,000 ft in deepest repressuring program*

WATER injection began recently in the world's deepest water flood of the North Lindsay Bromide sand unit of McClain County, Oklahoma.

The unitized block comprises 18 wells, drilled on a 40-acre spacing pattern making a total area of 720 acres. Production is from the Bromide sandstone at approximately 11,000 ft.

The unitized area has produced a total of 2,800,000 bbl of oil from the 18 wells in the unit. This was primary oil, produced by solution gas drive. Without secondary recovery, the Bromide sandstone can be considered economically depleted. It is estimated an additional 1,500,000 bbl of oil can be recovered by water flooding.

A water suppply well is being drilled now, with adequate supply of salt water expected between 1400 and 3800 ft. The water will be lifted by a high-volume bottom-hole centrifugal pump.

The salt water distribution system consists of a 6-in. trunk line with 4-in. lateral lines. All surface lines are cement lined to combat corrosion and to assure delivery of clean water to the input wells. Construction of the distribution lines and drilling of the supply well should be completed by the first of December.

This flood will be of the structure type, rather than the dispersed plan of injection. Initially, three low structural wells will be used for water input. Other input wells will be added as the water flood progresses.

In this deep water flood, where wells are widely spaced, stimulation of producing wells is expected at the end of approximately one year.

After approval was obtained to unitize operations on July 1, operators shut in wells with high gas-oil ratios and have taken the pool allowable from the lower-ratio wells.

The North Lindsay unit is in Sections 22 and 23, Township 5n, Range 4w. Cities Service is the principal owner, with other working interests owned by Anderson Prichard, Phillips, Mid-Continent, Sunray, W. F. Haynes, Aurora Gasoline, Nathan Appleman, Lindsay Corporation, Eason Oil, Zenith Petroleum and A. J. Lewis. Cities Service will operate the unit. * * *

### West Texas SACROC Project Set to Go

Oil and gas conservation benefits from the SACROC water and gas injection project for nearly 46,077 unitized acres in Scurry County, Texas are expected within six months, the Scurry Area Canyon Reef Operators Committee has been advised by its engineering subcommittee. These results are expected to come about through stabilization of bottom hole pressures and gas oil ratios.

A green light for proceeding with the line-type water injection in 53 wells that follow the approximate centers of the Canyon Reef production in the Kelley-Snyder and Diamond "M" fields, was given January 18 by the Railroad Commission of Texas. The injection of gas in three wells at the extreme north edge of the field is also part of the program to increase production at the most efficient rate over a long period of years. The Commission conducted an extensive and exhaustive study of the SACROC conservation program as presented on behalf of about 95 per cent of the operators and royalty owners involved in the field application.

SACROC and other engineers have estimated an ultimate recovery from the 1263-well field by primary means at approximately 667,000,000 bbl, but a total recovery under its authorized water flood program of more than 1.46-billion barrels, a conservation gain of about 795,000,000 bbl.

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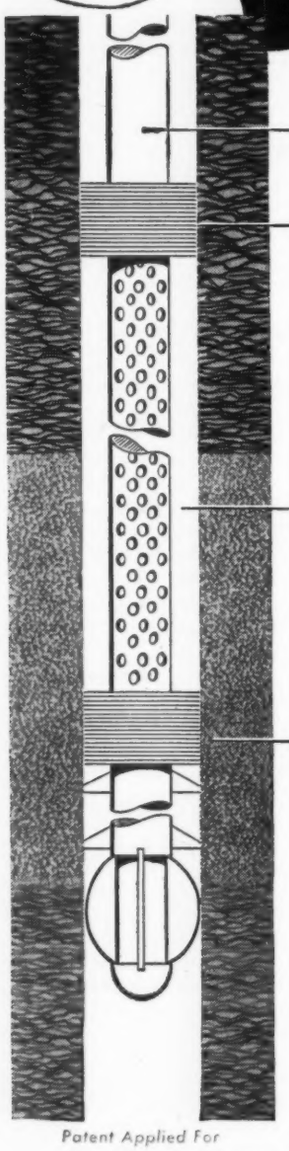


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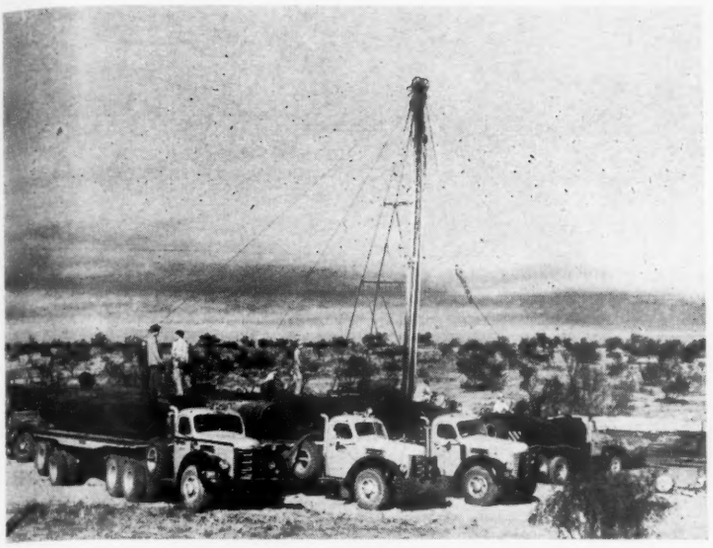
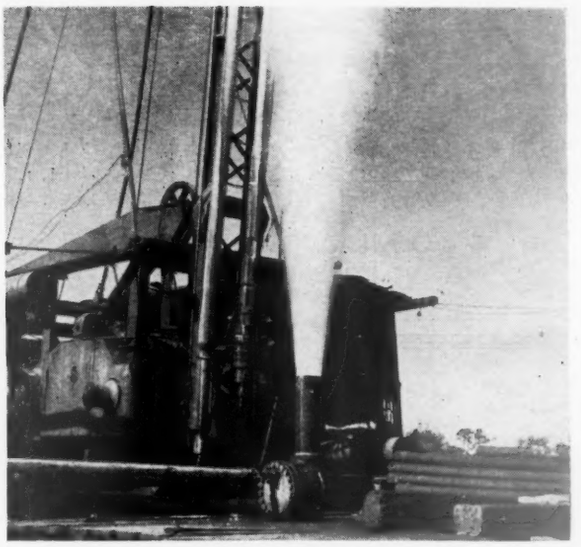


Many of the wells completed in the Morrow group have failed to produce in economic quantities until after a fracturing treatment, such as the one shown above.



The fracturing gel breaks down, depositing the sand in the fracture and returning to the well bore as a watery fluid, which is blown to the atmosphere.

*From Morrow Sands in Anadarko Basin,*

# Fracturing Boosts Gas Production

*Gelled acid-kerosine treatment has proved effective in converting marginal gas wells to commercial producers in Oklahoma Panhandle*

**R. J. COX* and R. F. WALL****

THE application of recently developed fracturing methods to sands of the Morrow group in the Anadarko Basin has resulted in sustained gas production in commercially profitable amounts. Many of the wells completed in this formation yield only marginal production upon completion; in some cases, only a show of gas being apparent. After fracturing, however, individual well production as high as 53,500,000 cu ft per day has been attained.

This new production is from Pennsylvanian age sands. Northwest of Guymon, Oklahoma, in Cimaron and Texas counties, gas is being produced from the Keyes and Purdy sands of Morrow group. Pay formations range in thickness from 6 to 20 ft. Southeast of Guymon, in Hansford County, Texas, and Texas County Oklahoma, the Morrow sand itself is gas productive. Although sands in the Morrow group have various designations in the field, here the Morrow group will include the Morrow, Purdy, Omohundra and Keyes sands.

With few exceptions, these wells may be called wildcats. Except for the Kelly oil pool, most wells are located on 640 acre spacing, some may be many miles apart. Although dry holes have not been uncommon, wells exhibiting a show of gas in the Morrow group usually have produced satisfactorily after fracturing.

The Morrow group is composed of very fine to coarse, angular-grained, quartz sand, usually containing considerable feldspathic material. As the acid solubility ranges from zero to approximately 19 per cent, these formations are inadequately stimulated by acidizing. Successful Stratafrac treatments in this region have employed an acid-kerosine gel containing sand, as the fracturing medium. Table 1 details the results of a number of these treatments.

Formation resistance to the fluid carrier is slight because of the relatively high permeability. Fractures, though difficult to obtain, have been achieved by maintaining a high injection rate. In most instances, however, the fracturing effect of the sand, coupled with dissolving action of the acid, have increased permeability sufficiently in the critical area for notable production increases. For example, well "B" increased daily production through 5½ in. casing from a mere show of gas to 19,000,000 cu ft, stabilized. Another, (well "C") two miles from a dry hole, was boosted from 132,000 cu ft to 13,800,000 cu ft stabilized.

### Stimulation Problems

In some instances, substantial initial gas production results promptly after perforating. A comparatively high initial flow of gas is an indication that the face of the pay is clean. Customarily, a mud acid wash has been necessary to initiate increased production by cleaning off the face of the formation, particularly when daily production is originally less than 2,500,000 cu ft. Follow-

*Station manager, Dowell Incorporated.
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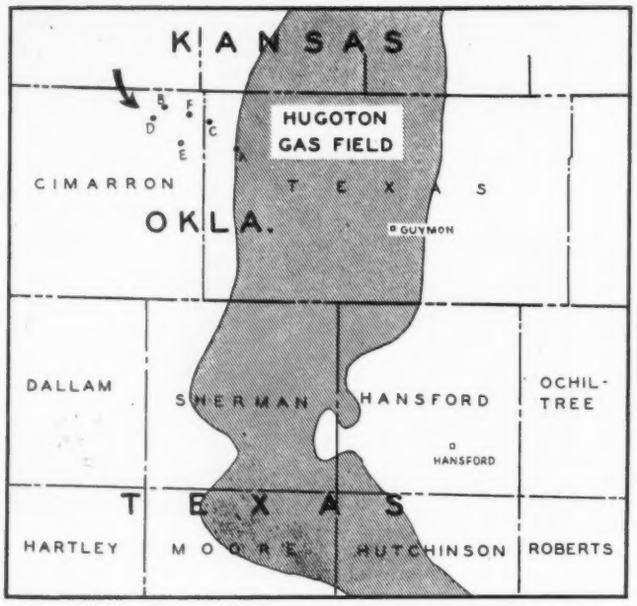
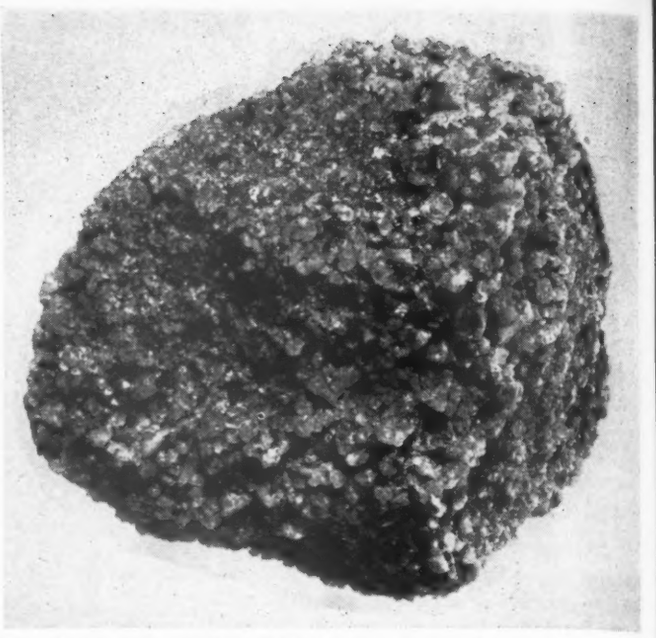



**New gas production is being developed from Pennsylvanian sands in the Hugoton area, considerably deeper than previous production from Permian reservoirs.**



**The Keyes sand consists of fine to coarse, angular quartz grains with silicate binder; while impractical to acidize, it responds well to fracturing treatments.**

ing the mud acid wash, rate of gas production tends to increase as gas is produced. Fracturing treatment may then be utilized to further increase production.

Morrow sand formations contain silicates that have a tendency to swell in the presence of water or acid. This swelling effect reduces formation permeability and, consequently, diminishes gas production. Special agents to prevent swelling should be included in the acid for optimum benefits. Water should be prevented from entering the producing formation.

### Treatment Procedure

Because most gas wells prove to be unique in one or more aspects, chemical treatment must be adapted to the individual well. Based on a number of successful stimulation treatments in the Morrow sands, however, certain general procedures have become established.

If initial production is not adequate after perforating, a mud acid wash is desirable. The mud acid, containing agents to prevent formation swelling, is pumped into the well and followed into the formation by a stage of wash acid. After all of the acid has been displaced from the tubing with water, spent acid is removed by swabbing.

Next, a comparatively small quantity (usually 500 gal) of the acid-kerosine gel, without any sand, is injected into the formation, preparing the way for the gel-sand mixture that follows. Treatments in this area have customarily employed ¾ lb of sand per gallon of fracturing fluid, and experience indicates that larger total quantities of injected sand result in greater and more sustained production increases.

A dilute acid solution, containing silicate control and surface tension lowering agents, is next pumped into the well to displace all of the gel into the formation. Enough water is then pumped in to displace the acid from the tubing, taking care not to inject water into the formation. After the gel has been displaced into the formation, it breaks down to a water-like consistency, dropping out the sand in the fracture to form a highly permeable channel to the well bore. The well is then swabbed, causing the carrying fluid to return to the well bore.

Treatments employing large gallonages and high injection rates have shown outstanding production increases. In order to obtain maximum benefits by injecting large gallonages at high rates, special pumping equipment is required. In one instance (well "F") three high-volume diesel pumps were employed, simultaneously. As this treatment was down the casing, friction losses were reduced, making it possible to get a fracture with lower treating pressures at surface. ★ ★ ★

**TABLE 1.**

| Well | Location | Depth, ft | Initial production, MCF | Stimulation method | Subsequent established production, MCF |
|---|---|---|---|---|---|
| A | Texas County | 4678–4694 (Keyes) | 1,720 | Mud Acid & Acid wash | 3,570 |
| | | | | Stratafrac | 7,000 |
| | (Set plug at 4500′ and re-perforated) | 4420–4430 (Purdy) | 1,320 | Mud Acid & Acid wash | 3,600 |
| | | | | Stratafrac | 4,000 |
| B | Cimarron County | 4623–4668 (Keyes) | no gas | Mud Acid | 690 |
| | | | | Stratafrac | 19,000 |
| C | Texas County | 4625–4640 (Keyes) | 132 | Mud Acid | 3,000 |
| | | | | Stratafrac | 13,800 |
| D | Cimarron County | 4427–4436 (Purdy) | Show | Mud Acid & Acid wash | 3,980 |
| | | | | Stratafrac | 14,000 |
| E | Cimarron County | 4512–4530 (Keyes) | 5,080 | Mud Acid & Acid wash | 15,000 |
| | | | | Stratafrac | 22,000 |
| F | Cimarron County | 4628–4644 4648–4668 (Keyes) | 4,000 | Stratafrac | 53,500 MCF through 5½″ pipe 110,000 MCF indicated open-hole flow w/back-pressure gauge |

### Drilling for Oil in China

The China News Agency states that in round figures 100 wells were drilled in the north-west and south-west of the country by geological prospecting teamse in 1953. Twice as many teams and drills were operating last year compared with 1952, and total footage drilled exceeded by 32,000 ft the depth of hole drilled the year before.—V.S.S.

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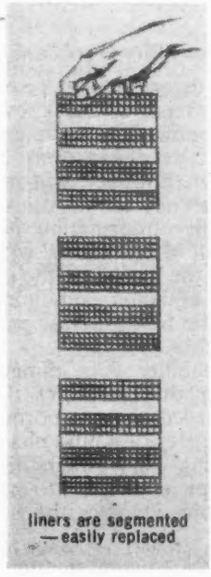

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*Conflicting Ideas on*

# Problem of Relative Permeability

*What further studies are needed? A summary of published data is given to aid engineers in answering this question*

WALTER ROSE

THE relative permeability problem is one which is far from understood, and its limits are far from being defined at the present time. This at least is a conclusion that could be drawn from a critical examination of the published literature and which is drawn in explicit fashion in this paper. The purpose of focusing attention on the confusion which evidence indicates exists about the relative permeability concept is two-fold. On the one hand, the publication of some 25 technical papers on methods of obtaining relative permeability data since Muskat's book[3] appeared in 1949 makes a more up-to-date presentation desirable for reference. On the other hand, the published conflicting viewpoints and inconsistent data of previous workers obsuring as it does the nature of what additional developments and research still needs to be done make a critical appraisal desirable for guidance. Thus, by reviewing what is known about relative permeability phenomena and what has been claimed. this paper gives reference and guidance material intended to provide perspective in the consideration of what new work still needs to be done.

**The Author**

Walter Rose is senior research engineer, production research division, Continental Oil Company. A graduate of the University of Chicago, he was formerly with Carter, and later Gulf Oil. He is a former lecturer in petroleum engineering at the University of Texas and presently an adjunct member of the graduate faculty at Oklahoma A & M.

### Relative Permeability Problem

The analytical description of reservoir performance requires the knowledge of relative permeabilities as one of the variables in the equations of motion. This paper, however, will not make explicit reference to the use of relative permeability information per se. Rather, it will deal largely with how, according to the literature, the information is to be obtained, combining for this purpose the best ideas of past workers in the field.[a]

Relative permeability is a dimensionless parameter that measures the conductivity afforded by a porous medium to the transfer of a fluid phase partially saturating the interstitial pores. The concept as applied to hydrocarbon reservoirs involves the use of reservoir rock as the porous medium of interest and the use of the oil, gas, and/or water existing in (or injected into) the reservoir rock as the fluid phases of interest.

At this point, the term relative permeability need be defined no further except to note as limiting conditions that a zero relative permeability implies that conditions are such that there is no transfer of the fluid phase of interest and that a relative permeability of unity implies that conditions are such that the conductivity for the transfer of the fluid phase of interest is the same as though this fluid completely occupied the pore spaces. Thus, while relative permeability is clearly zero when the saturation of the fluid of interest is zero, it may also be zero when the fluid saturation has finite values. Moreover, although the relative permeability clearly is unity when saturation is unity, it can also be unity at lesser saturations. As will be seen, it is conceivable that relative permeabilities greater than unity can obtain at saturations less than unity under certain conditions (cf. Yuster's paper[1] as one example).

In speaking of a finite value of relative permeability as a measure of a finite fluid conductivity, it is implied that, if forces are imposed in the direction which would tend to cause a transfer of the fluid of interest, there is a continuous or semicontinuous path along which this conduction can occur. It is thus necessary to give some attention to the types of forces that cause fluid transfer in hydrocarbon reservoirs and to the characteristics of the paths of conduction that exist in reservoir rock.

Fluid transfer occurs in hydrocarbon reservoirs, first back in geologic time during accumulation and later during the production period. There may also be some transfer of fluids subsequent to accumulation and prior to production, such as artesian flow in the water table.[b] The major forces responsible for this transfer will be those related to gravitational and capillary effects. They may also be due to the establishment of pressure gradients or to the existence of concentration or thermal gradients or to other diffusion effects. In any event, these forces all act in the direction of establishing conditions of stable or metastable equilibrium, whether such is ever obtained or not.

Fig. 1 depicts in a generalized manner the various ways a fluid phase of interest (or some component thereof) existing in a given system can be transferred from one point in that system to another (e.g., from point X to point Y). In particular hydrocarbon reservoir systems, the flow processes illustrated by cases 1, 2, and 3 will be of major importance as transfer mechanisms. Reflection will show that *transfer by flow* requires:

1. *The existence of some externally applied force or forces in the direction of flow, such as give rise to pressure or hydraulic gradients as are sometimes related to gradients in electrical potential (electrokinetic effects) or to thermal gradients causing density gradients.*
2. *A continuous path between the points X and Y along which flow can occur. This is illustrated by Case 1 where the path for flow is through the phase of interest which is being transferred or by cases 2 and 3 where the path for*

[a] A major objective of fluid mechanics research is to elucidate the performance of reservoir fluids in hydrocarbon containing reservoirs so that predictions can be made in advance of the recovery that can be expected from a given recovery process. If these predictions are to be made analytically, relative permeability information is required.

[b] Ref. M. King Hubbert's paper[2] on tilted water tables and the later analysis given by Yuster.[6]

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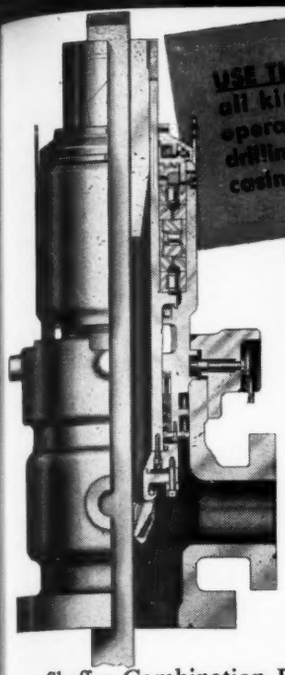

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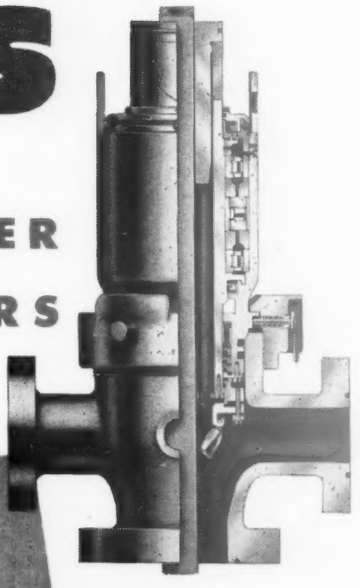

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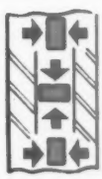

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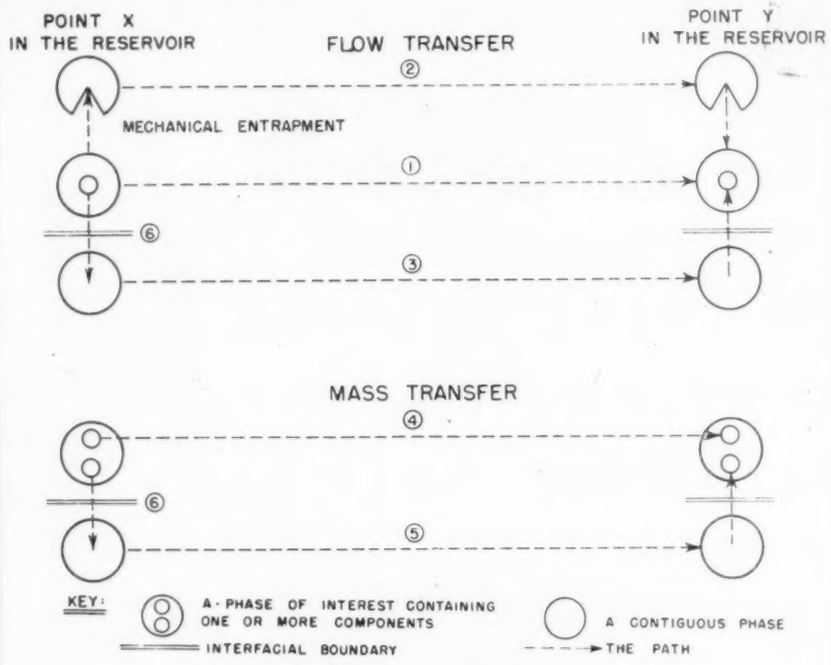



**FIG. 1. GENERALIZATION** of transfer methods of fluid phases within a system.

*flow is through some contiguous flowing phase connecting points X and Y.*

*In Case 2, the phase of interest is depicted in being mechanically entrapped at X in the flowing contiguous phase and transferred (via slug flow) to the point Y where it separates out. In Case 3, one or more components of the phase of interest evaporates, dissolves, or is extracted across the interfacial boundary into a flowing contiguous phase at point X and is deposited by these mass transfer processes (e.g., condensation or dissolution) at the point Y.*

Transfer can also occur by diffusion (viz. mass transfer) as is illustrated by cases 4, 5, and 6. Again certain conditions must be met before *transfer by diffusion* can occur, such as:

1. **Existence of a chemical energy potential, as for example is represented by a concentration gradient in the direction of transfer.**
2. **A continuous path between the points X and Y. through which diffusion can occur. This is illustrated in Case 4 where the diffusion path is through the phase of interest, in Case 5 where the diffusion path is through a contiguous phase, and in Case 6 where the mass transfer path is across an interfacial boundary.**

A third type of transfer that could descriptively be designated as *bucket transfer* involves the mechanical entrapment of the phase of interest and its transport in a container along a path which has nothing to do with the continuity of the phase of interest or any contiguous phase. Bucket transfer is further distinguished from slug-flow in that the forces causing transfer have nothing to do with the phase of interest. It is mentioned here only because one method of hydrocarbon recovery, viz. mining, involves the bucket transfer mechanism.

The consequence of transfer by flow being dependent on externally applied forces is that matter is not transferred between phases unless there is a phase change nor is one component of the flowing phase in motion relative to other components. Mass transfer, depending as it does on chemical energy, can occur across an interfacial boundary without reference to a phase change and can apply to separate components of a given phase even though there is no transfer of the phase as a whole. As reflection will show, most examples of transfer in hydrocarbon reservoirs involve both flow and mass transfer.

It is only when one type of transfer predominates that a simple description of the process can be given; moreover, obtaining a simple description often requires that the transfer be steady-state rather than transient, that the initial conditions be known, and that the boundary conditions have some element of geometrical simplicity. In a like manner, a more rigorous analysis can be given to laminar as opposed to turbulent flow and to gaseous as opposed to liquid diffusion. Isotrophy and homogeneity in the conducting medium also introduce simplicity.

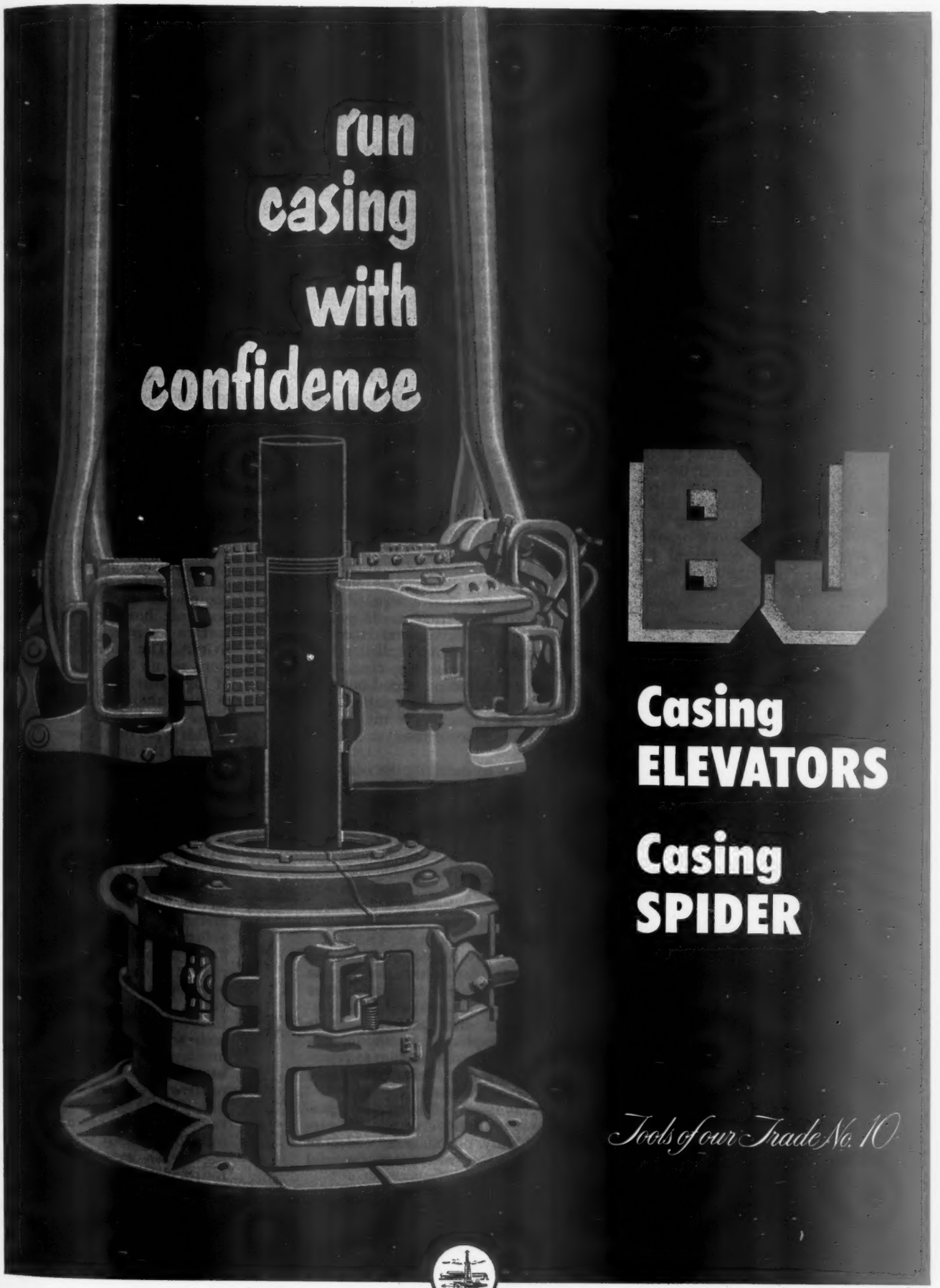
Although relative permeability data may someday be used to develop theories of hydrocarbon accumulation in underground reservoirs, data are now used principally in connection with the mechanics of reservoir production. At present, then, it is only necessary to give attention to the forces which are responsible for the production of oil and/or gas. For this purpose, one may examine a small volume element of the reservoir of interest as it exists at any given time during the production history; and it may be assumed that should any transfer of any of the interstitial fluids be occurring there, this transfer, for the most part, can formally be related to and expressed in terms of a pressure gradient in the direction of transfer. Some transfer may also occur by entrapment (as in the case in "slug flow") or by solution of one fluid in another. Capillary effects presumably can be neglected, since it may be postulated that, prior to the initiation of production, conditions of capillary equilibrium prevailed and that subsequently capillary equilibrium is preserved (except perhaps in the vicinity of the well bore) because of the slowness of saturation change with time. Transfer by diffusion can also be regarded as of negligible consequence. That is, in the production of underground reservoirs, mass transfer by chemical potential seems less important than transfer by the processes of flow.

Although the above discussion may provide an oversimplified picture of what is occurring, it will be seen that the problem of evaluating relative permeabilities is sufficiently complex to justify the introduction of some simplifying assumptions, such as the frequently used postulate that Darcy's Law is the "law of force" the fluid system must obey.[c] If this approach only gives approximate answers, a more elaborate analysis ultimately will be required, which will treat explicitly all the paths of conduction through which forces existing in the reservoir cause fluid transfer.

Relative permeability information is conveniently recorded by relating the conductivity afforded by a porous medium (to the transfer of a fluid phase of interest) to the fractional saturation of that fluid in the pore space. The latter is a parameter of only masroscopic significance, for it is well known that the fluid can be distributed in more than one way in the pore spaces for each value of saturation. The consequence of this is that the relative permeability-saturation relation is multivalued, exhibiting a hysteresis closely analogous to that observed in the capillary pressure saturation relation.

It is thus evident that the relative permeabilities associated with particular saturations must be further identified with the conditions of saturation distribution before the data can be used for the purpose of interpretation. Expressing this another way, it can be stipulated that to formulate a description of the mechanics of hydrocarbon production, one must determine the fluid conductivities as a function of saturation which hold under conditions of reservoir-like distribution of the fluids in the interstitial spaces. This is

[c] cf. "An Explanation of the Yuster Effect," by P. H. Scott and Walter Rose for an analysis of the limitations of this assumption. (J. Pet. Tech., November, 1953).

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no easy requirement, as will be seen. (cf. discussion by Rose.[29])

In the first place, if phase and capillary equilibrium conditions obtain, fluid distributions of immiscible fluids in porous media reflect the manner in which the equilibrium has been approached (viz., the past history). If equilibrium does not obtain, the fluid distributions reflect the past history as well as the interplay of the unbalanced forces. In any case, the best description of the characteristics of a particular fluid distribution in a particular porous medium is a statement of the history of the system where reference is made to the forces (causing fluid transfer and redistribution) which have been balanced and/or which are in a process of being balanced.[d]

A simplifying assumption that is usually made is that, in analyzing the recovery (production) of hydrocarbons from underground reservoirs, the system being dealt with is one where the interspatial distribution of the wetting and nonwetting fluids saturating the interstices is described by either the imbibition or drainage loop of the capillary pressure curve. Implicit in this is the supposition that the reservoir as it existed at the moment before production was commenced contained the fluids distributed in capillary equilibrium according to the drainage capillary pressure curve.[e]

Implied also is the concept that, whatever the mechanism of recovery, capillary equilibrium conditions are preserved during production by virtue of the relative slowness of changes in saturation with time (especially at points in the reservoir removed from the well bore). For example, when oil is produced by a bottom or edge water drive, imbibition type distributions can be expected to obtain, since the wetting phase (water) saturation is always increasing and the nonwetting phase (oil) saturation is always decreasing. Likewise, when oil is produced by a gas drive, drainage type distributions can be expected to obtain, since the wetting phase (in this case, oil) saturation is always decreasing and the nonwetting (gas) saturation is always increasing.[f]

The foregoing discussion (based on the premise that fluid distributions during reservoir recovery processes will always be either of the imbibition or drainage types) does not rule out the possibility that other types of distribution will be observed in certain cases. For example, the drainage type distribution obtained during oil production by dissolved gas drive is clearly different from that obtained during production by gas displacement. Moreover, if the oil is being replaced during recovery simultaneously by an advancing waterfront and by an advancing gas-front and/or by liberated solution gas, the fluid distributions will then be described by some intermediate curve in the capillary pressure curve hysteresis loop.

Finally, it is to be expected that some recovery processes will not be characterized by conditions of capillary and phase equilibrium. In this case, the spatial distributions of the immiscible saturants of the pore spaces will be of extremely complex type, the characteristics of which cannot be formulated (except indirectly by reference to the past history of the system).[g]

The consequence of all of this is the requirement that something be known of the reservoir system of interest before relative permeabilities can be evaluated, as required to predict future performance and recovery by the analytical equations of reservoir mechanics. Specifically, the system representing the reservoir problem of interest must be constructed to include the characteristics of the reservoir at the time production commences as well as the characteristics (viz., the forces effecting transfer) of the recovery process before the resultant effect of the recovery process can be studied.

In not a few cases, it seems as though if all the information were at hand to properly evaluate relative permeability, this information in itself would suffice to approximate reserves and recovery factors directly without explicit reference to relative permeability characteristics; and as has been pointed out, the only purpose of studying relative permeability phenomena is to make possible the estimation of reserves and recovery![h]

In addition to detailing the need for relative permeability information and outlining how the information is to be used in the solution of reservoir problems, Muskat's book[3] reviews all the research that was done up until late 1948 by workers investigating the relative permeability characteristics of porous media. It will be seen that three general types of approaches, then and now, have been advanced: These are:

1. **Laboratory model experiments of multiphase flow phenomena which make use of various types of porous media (such as unconsolidated sand packs, reservoir core samples, or synthetic consolidated porous media) to represent a volume element of the reservoir of interest.**
2. **Development of theoretical equations descriptive of relative permeability phenomena, which in those cases where experimental data are required for solution it is intended that the cost and/or the time required to obtain the data will be less than that involved in the direct determination of relative permeability. It is also intended that information obtained from the theoretical equations will have greater significance and acuracy than that obtained by other methods.**
3. **Field measurements of recovery at producing wells which can in certain cases be converted into relative permeability information.**

In subsequent sections, the approaches listed as (1) and (2) above will be discussed in greater detail by reviewing what has been done and, hence, what is known and, hence, what still needs to be done, in the way of future research and development. On the other hand, no extensive reference will be made here to the field measurement of relative permeability phenomena. This exclusion is not arbitrary but is based on:

(a) **The circumstances that phenomena occurring in the sometime fractured, acidized, and/or plugged sand face around the well bore, in the well bore itself, and in the surface production equipment introduce distortions which complicate the interpretation of reservoir flow conditions from surface observations of productivity.[4] The analytical expressions set up for this purpose are of high order complexity.**

(b) **A large amount of time and expense attends field measurements of this type, on the one hand because of the slowness with which stabilized conditions are obtained in a producing well and on the other hand because of the slowness with which reservoir conditions change. For example, days and sometimes weeks can be required to get a measure of the effective reservoir permeability by the pressure build-up method;[5] and years can elapse before the reservoir conditions of fluid saturation distribution change enough to get a second point on the relative permeability curve.**

(c) **Information about reserves and recovery is obtained from field measurements as easily as (and sometimes more easily than) is relative permeability information secured; hence the purpose for which the information is wanted is already satisfied, avoiding to this extent the necessity for special measurements of relative permeability.**

The foregoing, although it argues against the advisability of spending too much effort on the measurement of relative permeability in situ, does not discredit the observation that the great difficulty of undertaking reservoir model experiments in the laboratory and the great complexity of formulating theoretical descriptions of reser-

[d] For example, the best description of the distribution of oil in a virgin reservoir at some point in the transition zone between the water table and the upstructure region of maximum oil saturation (viz., the region of irreducible connate water saturation) is had simply by describing the approach to capillary equilibrium depicted by the drainage capillary pressure curve.

[e] The basis of this is the theory of reservoir accumulation which has led to the use of the drainage capillary pressure experiment to measure connate water saturation in the virgin reservoir.

[f] cf., Muskat[3] for a more elaborate discussion.

[g] cf., Material given by Brownscombe et al[24] in their section entitled "Application to Field Performance."

[h] The other oil industry use of relative permeability information as a tool to develop theories of migration of hydrocarbons from source beds and accumulation in structural and stratigraphic reservoirs has already been suggested. Beyond the scope of this report is the use of relative permeability information in chemical engineering studies of phenomena occurring in porous beds (e.g., filters, gas absorbers, and scrubbers).

voir performance, in a sense, make the reservoir itself the place one wishes he could go to gain some insight into what occurs macroscopically and microscopically during recovery.

Finally, while this paper is written in the belief that relative permeability information is both needed and, as yet, not easily obtained by experimental or theoretical methods, attention is called for completeness to the proposition that, in principle, model experiments of the recovery processes in the prototype reservoir can be performed which in the ideal case circumvent the need for explicit reference to relative permeability information (cf., discussion by the writer in reference 46).

## Experimental Approach — Early Work

The first important experiments on the laboratory determination of relative permeability undertaken by workers in the petroleum (production research) field were those reported by Wyckoff and Botset[6] in 1936. A number of earlier workers in the soil science field had been concerned with the flow of water (principally, a capillary imbibition type of flow) in soils at partial saturations.[1] Thus, Richards[7] in 1931 gave experimental data as well as theoretical information on this problem; and his pioneering work will be referred to again in the discussion which follows on Hassler's patented technique for relative permeability measurements.[8]

On the other hand, the Wyckoff and Botset paper followed by the Leverett paper[9] in 1939, the Botset paper[10] in 1940, and the Leverett and Lewis paper[11] in 1941, constitute all the reference material that must be examined to review what was known about measurement of relative permeability prior to World War II. This excludes as reference material a number of other prewar papers,[j] which dealt with special condition experiments not constituted to reveal fundamental information.

In their work, Wyckoff and Botset (loc. cit.) employed a long (10-ft) horizontal tube which was filled with a clean unconsolidated sand and provided with means of measuring pressures and electrical conductivities at intervals of about 15 cm. Mixtures of water and carbon dioxide were flowed through this sand tube in various ratios.[k] For any given ratio of water and carbon dioxide, a steady rate of input was maintained until the ratio of fluids discharged became constant with time. While the fluids were flowing, the electrical conductivity of the system was measured. The fraction of the pore space filled by water was determined from these conductivity measurements with the aid of a calibration chart which resulted from auxiliary experiment.

The experiment of Leverett (loc. cit.) differed from that of Wyckoff and Botset in that a short vertical tube was used rather than a long horizontal one; and while the conductivities of several sections of the vertically mounted column could be measured, only the total pressure drop across the column could be ascertained. Leverett also used an oil instead of gas as the nonwetting phase.

The procedure followed and the equipment used by Botset (loc. cit.) on his work with the Nichols Buff sandstone was in all major respects identically the same as in the case of the earlier Wyckoff and Botset work. Likewise, Leverett and Lewis (loc. cit.) patterned their three-phase (gas-oil-water) relative permeability experiments after the earlier Leverett and the still earlier Wyckoff and Botset work. In brief, all of these experiments might be described by saying that mixtures of two (or three) fluids were flowed through the permeable media chosen to represent the hydrocarbon reservoir. When these fluids reached a condition of steady flow, the drop in pressure across a fixed distance was measured. Within this interval, the water saturation was determined by an electrical conductivity method.

Reference to these four papers will show that a remarkable amount of information was obtained (cf. pages 274-302 of reference (3) bearing on the dynamics of multiphase flow in porous media. A discussion of these features is beyond the scope of this paper, however. Rather, there is to be answered the questions: Are these early experimental procedures still of use, and do these early experimental data still deserve attention. Affirmative answers can be found in many cases, it will be seen.

In the first place, enough is now known to realize that the solution of particular reservoir engineering problems requires the determination of the relative permeability characteristics under reservoir flow conditions of core samples representative of the reservoir of interest. In this sense, the cited early experiments of the Gulf (Wyckoff and Botset) and Humble (Leverett and Lewis) researchers were deficient in both respects. While the Gulf technique of developing the gas saturation by gas evolution may have given gas-liquid distributions similar to certain sometimes occurring conditions, the same cannot be said about the Humble technique of dynamic displacement without further proof. In no case, moreover, did these workers use a porous medium in their experiments representative of known reservoirs of interest. While reserves of hydrocarbons are sometimes found in unconsolidated sands (e.g., the late Miocene deposits of the Lake Maracaibo Region, Venezuela), these naturally occurring sands are never of uniform grain size and seldom free of hydratable clays dispersed on the interstitial surfaces. In a like manner, the consolidated Nichols Buff sand secured by Botset from an outcrop in Ohio was washed with acids to remove ferric oxide as well as the calcareous fines on the pore surfaces and thus was not even representative of the Nichols Buff formation which is sometimes oil-bearing in the Apparachian Region.

In the second place, it can be said that the conductivity method employed by the early workers for measurement of wetting phase saturation deserves wider use in present day studies with small cores because of the reference material obtained thereby for electric log interpretation.[1] Similarly the early work with long cores suggests that the use of small cores in series might simplify experimental work in present day experiments; and the Gulf use of gas evolution as a displacement mechanism in laboratory experiments has a definite bearing on present day work (cf. Brownscombe et al[24]) once supersaturation effects are better understood.

## Experimental Approach — Modern Work

Although there were some miscellaneous small core experiments reported,[13] the first major relative permeability work undertaken in the postwar years was that at Penn State[14,15,16] which led to the development of the so-called Penn State method. This method was simply an adaptation of the earlier techniques employed in the unconsolidated sand column work which had as a major premise that, when steady state mixture flow is achieved after a dynamic displacement process, then the interspatial fluid configurations will be equivalent to reservoir conditions; and hence the relative permeability data obtained will be relevant to reservoir problems. Latest experiments of this type were done by Osoba et al,[17] Caudle et al,[18] and Geffen et al[19] in 1950 and by Josendal et al[20] and Richardson et al[21] in 1951.

No detailed analysis of this work is warranted at this time until further experimental work resolves some of the contradictory statements reported in the literature. For example, some workers observed saturation variations along the length of the core[19] and others did not.[21] Some workers found a rate effect[18] and others did not.[19] Most agreed that the boundary effect could be minimized or otherwise accounted

[1] Agricultural and soil scientists have continued to publish on multiphase flow problems but much of it has no bearing on petroleum production problems, and hence only occasional literature citations will be found in this report to their work. By and large the most important references dealing with experimental procedure are to be found in the literature of petroleum technology with occasional references in the chemical engineering literature.

[j] cf., E. W. Dunlap, Trans. A.I.M.E., Vol. 127, page 215, (1938); L. S. Reid and R. L. Huntington, Trans. A.I.M.E., Vol. 127, page 226, (1938); F. B. Plummer et al, *The Oil and Gas Journal*, page 42, April 8, 1937; L. C. Uren and E. J. Bradshaw, Trans. A.I.M.E., Vol. 98, page 438, (1932); L. C. Uren et al, Trans. A.I.M.E., Vol. 114, page 25, (1935); G. L. Hassler et al, Trans. A.I.M.E., page 116, (1936); N. van Wingen, Trans. A.I.M.E., page 205, (1939); W. F. Cloud, Trans. A.I.M.E., Vol. 86, page 337, (1930); I. I. Gardescue, *Petroleum Engineer*, Vol. 4, (Nov., Dec., 1932; Jan., Feb., (1933); H. Krutter, Producer's Monthly, Vol. 6, page 25 (June 1941).

[k] An important detail of the procedure to note is the fact that most of the flowing gas was solution gas liberated by pressure reduction. When high gas-water ratios were desired, some additional gas was injected at the inflow end of the column.

[1] In three-phase work, the saturation of two of the phases must be independently determined so that the saturation of the third phase can be obtained by difference; hence the probability that the conductivity method will find wider use when three-phase work becomes routine.

for,[17,18,19,21] and all implied that the simplicity of the method (over the Hassler technique) made it attractive. Two authors[20,21] showed equivalence between Penn State and Hassler type data, but Osoba et al[17] observed that wetting liquid relative permeabilities by the Hassler method were "consistently lower" than results obtained by the Penn State method.

It can be said in summary that the use of the Penn State method is limited to the extent that saturation distribution along the flow path varies. This is true even in the case where the boundary effect has been made negligible. Moreover, should ways be found to achieve a uniform saturation gradient in the test portion of interest, it must still be proved that the type of fluid distributions which obtain in the Penn State dynamic flow system have any equivalence to reservoir conditions. In any event, the above reported experimental finding that Penn State and Hassler techniques give reasonably similar results is not in accord with theoretical expectations,[m] hence further research and development on the Penn State method is perhaps warranted, but evidently this should be deferred until reliable Hassler techniques are perfected as will be discussed below.

[m] When measurements are being made under conditions of low capillary pressure (e.g. when the saturation distribution is described by an imbibition curve) the capillary pr ssure gradient, and hence the saturation gradient will likewise be low; and $K_R$ values obtained by a dynamic method may seem to approach values obtained by the Hassler method. In no case does this constitute exact equivalence, however.

The historical sequence of research on the application of Hassler's technique for relative permeability measurement was as follows. Hassler's patent[8] appeared in 1944 patterned closely after the concepts originally set forth by Richards.[7] Bulnes and Fitting[22] presented a mass of relative permeability data in 1945, and a subsequent private communication implied the data were obtained by Hassler's method. The first two papers on Hassler apparatus and technique (or modifications thereof) did not appear until 1949,[23,24] followed closely by five more papers in 1950[25,26,27,28,17] and four papers in 1951 and 1952.[20,21,29,30] These papers are all premised on the belief that capillary equilibrum between immiscible fluids obtains in reservoir flow; hence capillary equilibrium should be provided for in the laboratory experiment as is the case when the Hassler technique is employed.

An examination of the literature gives the reader the impression that most investigators think the Hassler technique in theory is the proper way to measure relative permeability but that most data are today being obtained by the Penn State (or equivalent dynamic) method. If the reason for the latter is simply the inherent simplicity of the practice of the Penn State method, the reason is no more defensible than the sometimes used, albeit fallacious argument that reproducibility in relative permeability measurements is proof that accurate values are being obtained. If the reason is (as some have claimed but theory contradicts) that both methods give essentially the same result, use of the Penn State method is then indicated as a matter of experimental expediency and nothing more.

A more explicit statement to support the use of the Hassler technique can be given, however. Relative permeability data are obtained using small core samples to define the mixture flow in the small volume element of the reservoir represented by the core. Since reservoir saturations change slowly with time, it can be assumed, first, that during all increments of time the flow through the reservoir volume element will be steady state and that it can be suspected; second, that there will be some form of dynamic capillary equilibrium between the immiscible phases.

Hassler's use of semipermeable pads in contact with the core sample is presently the only known method to provide for this second requirement in laboratory experiments; and while the Hassler experiment is usually practiced with the interspatial distribution of fluids as some point on either the drainage or imbibition loop of the appropriate capillary pressure curve, there is nothing that says that other configurations as defined by some intermediate point within the hysteresis zone cannot also be used. The point is that the Hassler technique and only the Hassler technique makes mixture flow measure-


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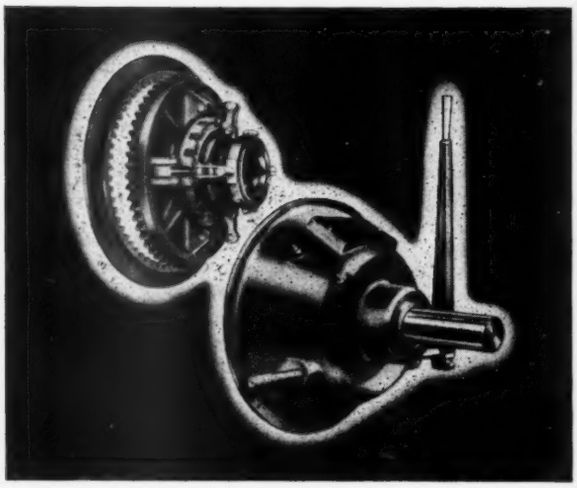

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ments possible under conditions of zero saturation gradient. Type of interspatial distribution of fluids is, of course, to be chosen according to the type of reservoir being studied.

That a number of serious instrumentation difficulties are encountered in the practice of the Hassler method is implied by the data anomalies that certain workers have reported and in more detail by the analysis of this subject which the writer has previously given.[29] The fact that each new worker in the field tries a different modification of the Hassler technique to get satisfactory data is also evidence that the problems of measurement have not been solved.[n] Further research and development are thus indicated. Approaches that might be tried are: The Hartwig method,[30] the series method,[23,26,29] the adjustable manometer method,[29] the use of low capacitance manometers,[29] methods which hold one or more phases immobile or otherwise "frozen" in place,[17,23] long core methods,[21] radial-flow methods, the Hafford method,[21] and the like. These approaches have been proposed as ways to simplify the problems of measurement. There is still to be done work on compaction effects (cf. I. Fatt and D. H. Davis, "Reduction in Permeability with Overburden Pressure," J. Pet. Tech., December 1952).

To conclude this review of modern experimental work, brief reference should be made to certain miscellaneous experimental work which has been done for special purposes.[o] An example of this is the writer's work[31] on gas slippage effects which was later verified by other research.[23,32,33] Other examples are Yuster's recent work on relative permeability problems[1,34] and the papers on steady flow of two-phase, single-component fluids in porous media.[35,36,37] Of interest in these connections is the conclusion one draws that development is needed of several types of relative permeability experiments to obtain data on the several types of reservoir recovery processes. (cf., the views expressed by other recent writers[19,50]).

[n]There is accumulating considerable evidence that workers in one laboratory cannot reproduce the work reported from other laboratories. While this is not explicitly evident from current publications, it would indeed be surprising, for example, to find relative permeability curves checked by laboratories which had difficulty in checking porosity values (c.f. B. J. Dotson et al, Trans. A.I.M.E., 192, 341, 1951).

### Equations for Relative Permeability Indicated by Theory

The historical development of the theory of relative permeability calculation will call attention nicely to the confused situation existing at the present time.

Rose and Bruce[38] proposed an equation for wetting liquid relative permeability which among other things was fallacious, as Thornton[39] later showed, in its disregard of the increased tortuosity associated with reduced wetting liquid saturations. Thornton, however, repeated an error in the Rose and Bruce work by using the ratio of the capillary pressure to the interfacial tension as an expression for the specific surface area (per unit pore volume) bounding the wetting liquid.

This error is indicated simply by a consideration of the fact that the specific surface area should pass through a maximum in the interval of zero to full wetting liquid saturation. In order to obtain better conformance with experimental data, the equation of Rose and Bruce was modified by Rose[12] in the arbitrary manner of postulating as general what is known to be a nongeneral expression for the variation of capillary pressure with saturation. The recent Rose and Wyllie equation[40] similarly is related to the Thornton equation by a nongeneral capillary pressure function, and one might conclude in this regard that arbitrary modification and simplification of what already are shown to be fallacious expressions has dubious merit. Gates and Lietz,[25] Rapaport and Leas,[27] and Childs and George[41] have made other derivations of theoretical equations, which it might be noted repeat the error of the Rose and Bruce expression by neglecting tortuosity considerations.

Of these latter authors, all but Rapaport and Leas appear to be cognizant of this ommission, for Rapaport and Leas state, as a major premise of their

[o]A.P.I. Project 47 files should be referred to for additional reference material. (cf., M. Muskat, F. Chatenever, and Norman Hackerman, Proc. A.P.I. Meeting, Chicago, 1953).

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theory, that the flow matrix is defined completely "by its inside surface area and volume per unit bulk volume," implying pore shape and tortuosity is of no importance. Other authors,[12,25,41] while not including tortuosity parameters in their equations, are careful to indicate the need for such correction;[p] and Fatt and Dykstra[26] have published recently to correct the Gates and Lietz equation in this regard (albeit in what Fatt and Dykstra themselves suggest is an arbitrary manner).

Finally, it should be noted that these latter equations[25,26] have been erroneously derived in that a saturation term is missing.

The intent of all of the foregoing cited work, of course, has been to provide a substitute for the sometime laborious techniques of laboratory measurements (particularly wetting liquid relative permeability measurements) and also to derive greater understanding of the detailed aspects of multiphase flow mechanics. One might question, however, the necessity for so many equations which fundamentally are in disagreement each with the other; and one might regret that the previous writers on this subject have taken so little pains to show the special merit of the new equations they have proposed (cf. discussion by Wyllie and Spangler[42]).

In any event, it would appear that any equation developed as an expression for relative permeability should be judged (before acceptance) by three criteria, namely, the conformance it gives to reliable experimental data; whether or not the relative permeability information sought is more easily obtained by application of the equation[q] or by direct experimental observation; and finally, is the equation in accord with fundamental theoretical considerations. Wyllie and Spangler[42,47] and to a lesser extent Burdine in more or less equivalent work[43] appear to be the only workers to date who have seemed to have these criteria in mind.

It is simple enough to conclude that much remains to be done before expressions for relative permeability are derived that will consistently provide adequate description of *reliable* experimental data (and therefore serve as a convenient substitute for experiments) and which at the same time will be in accord with basic theoretical requirements (and therefore have utility in the interpretation of mixture flow phenomena). One approach to the problem might be to develop further empirical correlations of the type reported by Brownell and Katz[44] once the experimental problems of measurement are solved and experimental data are available for examination. Other approaches might be in the nature of refinements in the theory already advanced by the authors cited above.

The latter would seem to involve only discovering ways to use the formulation:

$$K_R = \frac{S\,(A_1)^2\,(t_1)}{(A_s)\;(t_s)} \quad . \quad . \quad (1)$$

Where $K_R$ and S are the fractional relative permeability and the fractional saturation, respectively, of the fluid of interest; $A_1$ and $t_1$ are the specific surface area (per unit pore volume) and the Kozeny texture factor, respectively, as they apply when $S = 1$; and $A_s$ and $t_s$ are these terms as they apply at partial saturations (viz. $O \leq S \leq 1$) of the fluid of interest.

The above expression is obtained in the straight forward manner of dividing the Kozeny equation for effective permeability at partial saturations by the Kozeny equation which describes flow when $S = 1$, and its use only depends upon the availability of ways to independently evaluate the terms $A_s$ and $t_s$, since $A_1$ and $t_1$ are known constants of the system. That there is no general agreement as to how $A_s$ and $t_s$ are to be evaluated is in part evident from an examination of Fig. 2, which has been constructed to compare the predictions of several authors for the following typical case.

A hypothetical porous medium was considered having 25 per cent porosity and 20 per cent irreducible wetting liquid saturation, $S_M$. It was then assumed that the tortuosity ratio, $t_1/t_s$, is given by the square of the wetting liquid saturation, $S^2$, as Thornton[39] suggests should be true in some cases; and it is assumed that the capillary pressure to displacement pressure is given by $[(1 - S_M)/(S - S_M)]^{1/2}$, where this function is a generalized form of the equation given by Rose and Wyllie.[40] Wetting liquid relative permeability curves were then calculated by the methods of Rose and Bruce[38] (Curve 1), Thornton[39] (Curve 2), Rose[12] (Curve 3), Rose and Wyllie[40] (Curve 4), Gates and Lietz[25] (Curve 5), Rapaport and Leas[27] (Curve 6), and Fatt and Dykstra[26] (Curve 8). The lack of conformance is evident from Fig. 2, which inspection will show is not a consequence of the arbitrary assumptions made about the nature of the hypothetical system which was considered, but is due to the continuing disagreement among authorities as to how equation (1) is to be applied in specific instances.

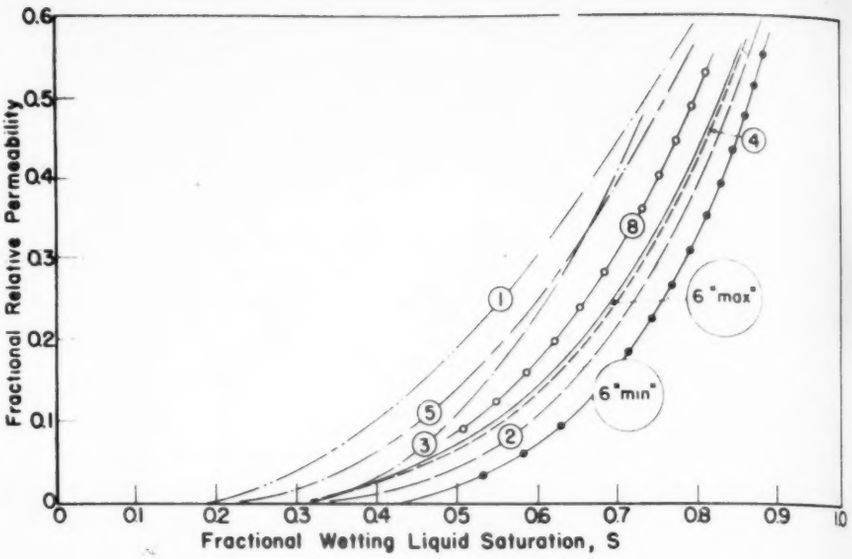


**FIG. 2. PREDICTED** relationship between relative permeability and wetting liquid saturation according to various authors.

If Kozeny-Carman concepts[r] are to be used as the basis for formulating an "effective" permeability expression, attention should be given to Carman's[45] assertion that the following conditions should hold:

(a) No pores are sealed off
(b) Pores are distributed at random
(c) Pores are reasonably uniform in size
(d) Porosity is not too high
(e) Diffusion, surface, and slippage effects are absent

Condition (a) causes no difficulty as long as saturations are expressed in terms of "effective" rather than total porosity. Carman notes that condition (b) may not be satisfied in the case of stratified media, such as comprise many petroleum reservoir sands. In general, however, in studying reservoir behavior, one is concerned with only one direction of flow so that stratification and the consequent dependence of texture on direction of flow introduces no error.

In connection with condition (c) Carman notes that "nonuniformity of particle size . . . does not necessarily mean nonuniform pores, particularly if *proportions* are distributed evenly over the range of sizes." Nonetheless, it is probable that extreme variations in pore size characteristics such as would obtain in media of intermediate or foraminiferal type porosity would completely vitiate the application of Kozeny-Carman theory in these in-

[p] A. C. Bulnes in his written discussion of one of these papers[12] is perhaps to be credited with having first called attention to the importance of tortuosity.

[q] N. B., in most cases use of presently proposed theoretical equations still require securing some experimental data for their solution.

[r] cf., Discussion by M. R. J. Wyllie appended to the translation of Kozeny's paper published by the Petroleum Branch, A.I.M.E., 1953.

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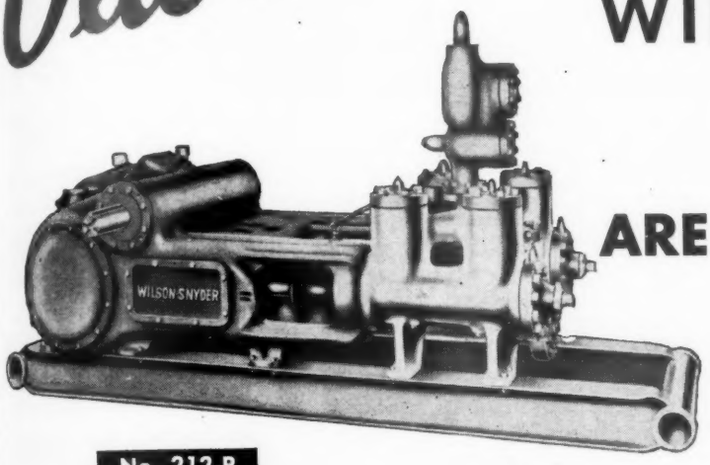


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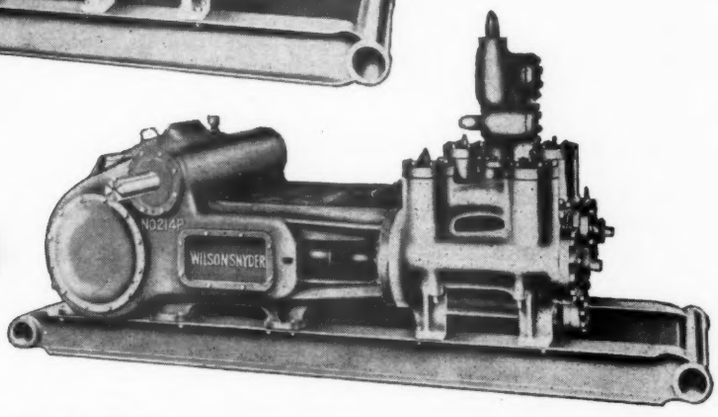


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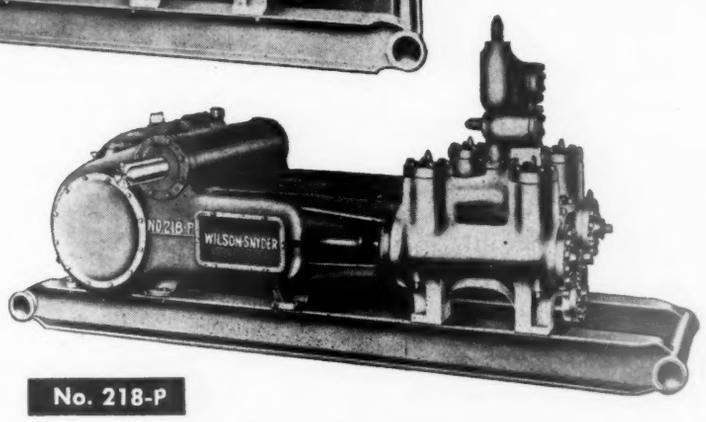


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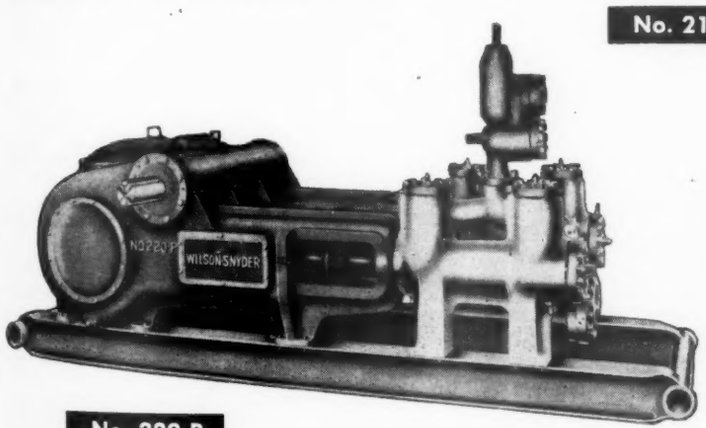


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stances. Condition (d) implies Kozeny-Carman theory breakdowns for fundamental reasons at porosities greater than 80 per cent which is well above the range encountered in the media comprising petroleum reservoirs. Condition (e) when not fulfilled results in departures from Darcy's Law as well as from Kozeny-Carman theory and in this respect involves considerations unnecessary to treat here.

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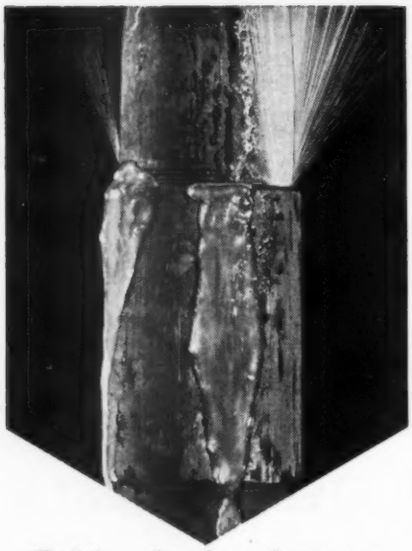

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# Employee Relations in the Contract Drilling Industry

*Scattered operations and isolated characteristics make personnel problems in this industry different from all others*

A. H. BELL*

BECAUSE of its peculiarly isolated character, much of the drilling contract business offers aspects of personnel and industrial relations that are quite different from those in the experience of other segments of the industry. There may be groups, perhaps, such as geophysical and other exploration parties, that are subject to similar periods of intermittent and nomadic service, but on the whole the drilling contract crews are involved in a species of endeavor that has its own distinctive operational and environmental conditions, and consequently its own inherent problems. Contract drilling, however, is no longer a new industry, and the accumulation of experience is now sufficient to permit a much more logical treatment of its diverse labor relations problems, internal and external, than was formerly possible.

One of the more pertinent considerations of which the established operator today takes serious cognizance is the binding, in so far as it can be done, of his scattered elements into a cohesive whole. Communications have been greatly improved in the past decade, and with radio equipped field cars, inter-departmental telephonic facilities, and other types of fast information exchange available, much can be done to dissipate the sense of lonesomeness that in other days played havoc with the important matter of labor turnover.

With rigs scattered widely and crews working even in the most inaccessible places today, there is usually continuous contact between headquarters and the men on the rig. It would be difficult to say how much this has affected the morale of the workers, but there is no question that men who know they can contact their homes in case of emergency and can keep, at least to some extent, informed on what goes on in their particular little worlds, can perform much more effectively than they do when they are completely out of touch. This tie-in with their cities and homes has a safety and security angle, too, that has a most beneficial reaction. The man on the rig knows that the big boss is interested in his physical well being, and should he become seriously ill or be badly injured on the job, the news can be immediately relayed to headquarters. Thereafter, no matter how far he may be removed from headquarters, he can be picked up in a plane or a helicopter and whisked to the hospital almost faster than if he were being taken from his city home.

It is unfortunate that by its very nature contract drilling is a sporadic business that at times lacks continuity. It thus is no easy matter to hold good men on the crews, and everything that can be done to avoid interruption of the rig schedule should be done. Scheduling of jobs so that a new location is always ready when one well is completed, and the assignment of drilling jobs in the same general area to rigs already working in that area, are concessions in this direction that are perhaps hardly worth mentioning. It is, however, quite impossible to assure constant employment in the drilling contract business, and the only thing that management can do is to choose the right people and then make the job as attractive as it can be done economically.

There are many little things that have tremendous effects in this regard. It has been my experience that the three most important items in the maintenance of employee morale in outpost work are money, mail, and food. Pay checks should always be made up on time and actually delivered into the hands of the worker on time or deposited as instructed by him in such a manner that he knows the deposit has been made. There is nothing more damaging to the productiveness of a worker than the mental unrest that comes with a missing paycheck or one that is not made out in the right amount. Time cards should be turned in to the accounting department with the very minimum of delay. Thereafter, they should be completed with the same expedition, and the check should be handled as instructed on the appointed pay day, whether the man involved is going to be out on the job for six days or six years.

The disconcerting and disturbing effect of delayed mail cannot be emphasized too strongly. Many a good crew man has quit his job in a frenzy of apprehension because some thoughtless clerk has pigeonholed the letter that he was expecting from his wife or sweetheart, or has failed to pass on to the family some relayed message from the worker. The food problem is one that normally takes care of itself, but there are situations in which it is impossible to secure within a reasonable radius the kind of victuals that a husky crew member needs to exert his best effort. The employer in such an instance would be well advised to exercise some concern, and also some effort, to see that adequate supplies are made available.

The dispersed nature of ordinary contract drilling operations precludes any kind of centralized training either in safety or working techniques, but to an extent, at least, this can be offset by the simple use mimeographed instructions, or lettergrams, transmitted through the tool pushers to the men on the rigs, with the general understanding that they will further advise and explain where that becomes necessary. Bulletins of this sort can be extended to carry personnel news, progress reports, items on significant policy developments and changes, and any other news that might help to make the men feel just a little more that they are really an integral part of the total operation. With the prevalence of radio broadcasting, the men can be apprised of world happenings in the dog houses even if it is necessary to provide battery sets where no electricity is available.

The tool pusher is a mighty important individual in a set-up of this kind. He is in reality the representative of management on the job, and if he is

*President of Bell and Burden, Inc.

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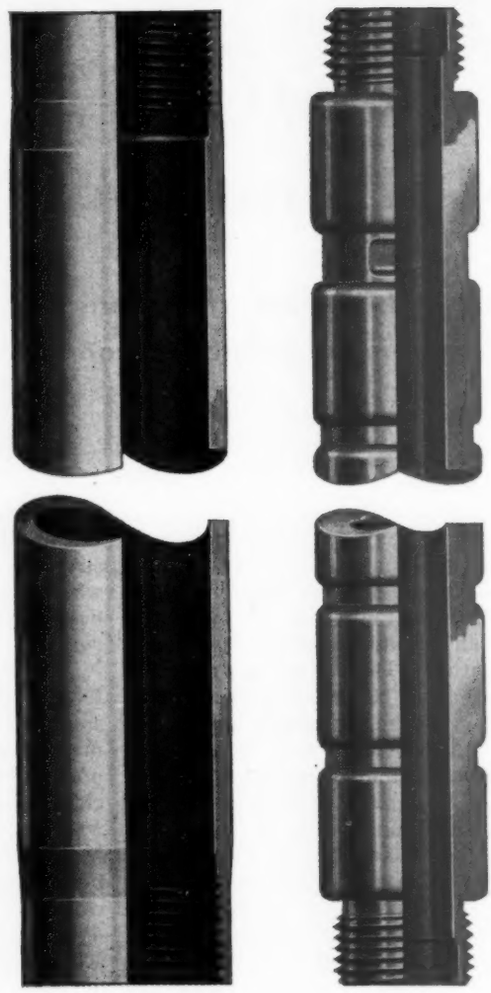

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not already imbued with the qualities and traits that are necessary in the diplomatic matter of handling men away from home, some intensive training for him along that line would constitute an expenditure of time and interest very much worthwhile. Although it is highly important that he be thoroughly familiar with operational techniques and safety rules and regulations, it is equally important that he have the humanitarian instinct that will impel him to counsel wisely and well with the men when they are in need of such counsel. Away from home, men can brood themselves into all sorts of distresses, and restored confidences and regained equanimities not only result in greater work output, but reduce the chances of accident immeasurably. An outpost worker who is ill at ease because of some domestic situation, either real or fancied, is what the wisecrackers with more truth than poetry call "an accident just about to happen."

Ordinarily, the pusher is a man who has been a top driller and he is thoroughly familiar with the routine of the drilling operation. In a contract firm, however, with, say 20 rigs working in widely dispersed areas, it means that the 20 pushers involved have to take on new responsibilities, such as the hiring of crew members, the ordering of special and emergency equipment, and the making out of accident and other reports. A prior intensive school course with the subsequent provision of an instruction manual is of distinct help in standardizing procedures and giving the pusher something definite on which to base his decisions. His ability to handle policy matters with forthrightness will also have the effect of instilling confidence and respect in his men.

Plans for bonuses, profit-sharing, vacations, pensions, medical attention, and other types of employee benefit are effective means of building morale. They constitute, however, a subject in themselves, and I can only say here that while they are ideal for investing employees with a sense of partnership that is undeniably a good thing for almost any business, the lack of continuity of contract operations, the widely scattered locations, and the consequent high labor turnover, make the application of such measures very difficult in many instances.

Because of the difficulties referred to above in offering various types of employee benefits, and particularly those benefits that are known to the employees to be available in other industry organizations, it is more than ever incumbent on contract drilling management to make systematic studies of the problem. Substitute plans can and should be considered wherever that can be done economically in the effort to

develop comparable security arrangements. With the present scarcity of qualified personnel, the contract drilling industry must take such steps as can be taken rationally to keep its competitive position in the matter of personnel procurement on the most favorable basis and there is no doubt that medical benefits, hospitalization allowances, and other such providental measures have an important bearing on the obtaining and maintaining of an adequate operating force.

Despite the most favorably disposed management, outpost drilling imposes hardships that are definitely out of the ordinary, and it is possible that about some of them nothing can be done, but to endure them. Under such circumstances a display of concern, if it is genuine, on the part of the employer may spell the difference between loyal, productive, lasting crews, and the dissatisfaction that makes for short term association. Conditions, both working and resting, should be as safe as possible, and at least reasonably comfortable. Equipment on the rig should be free from defect, and all of the recognized safety precautions and devices should prevail.

And here, perhaps, we should more strongly emphasize that this discussion relates only to the contract driller whose rigs are intermittently occupied in widely dispersed areas. There are firms that operate almost continuously and within fairly confined territorial limits. These, of course, are quite similar to static plants or organizations, and can apply standard industrial relations practices. They are dealing with long term employments, and all the normal considerations of a well established and well anchored business and their problems are entirely different from those encountered by the intermittent outpost driller.

It should also be emphasized that this is merely a sketchy reference to an existing condition, and is not intended to offer a well ordered program of conduct. Actually, for the type of contract drilling that we are discussing, each firm has its own peculiar problems, and each must develop its own approach. We have merely cited some of the difficulties that may be common to all, and find our justification for this effort in the belief that every such treatment is stimulative of more study. There are few problems even in contract drilling so insoluble that they can't be resolved by systematic study. * * *

☆ ☆ ☆

A newlywed filling out his income tax return listed a deduction for his wife. In the section marked, "Exemption claimed for children," he pencilled the notation, "Watch this space."


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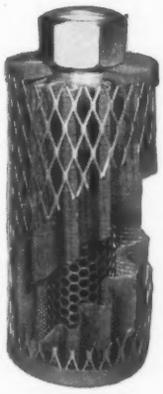

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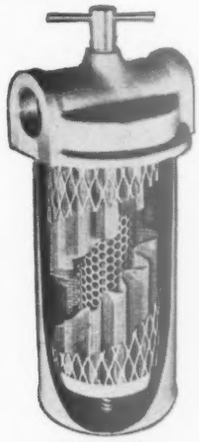

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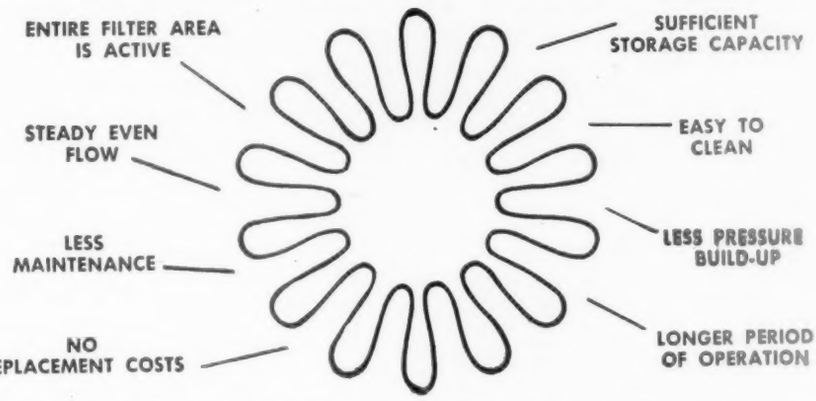


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# Quantitative Evaluation of Rock Porosities by Neutron-Neutron Method

JAMES H. RUSSELL and BRYAN O. BISHOP

IN 1952 a paper was presented, "Radiation Logging and its Application in the Oil Fields"[1] which for the first time presented a new method of neutron-neutron logging and pointed out the differences between the neutron-gamma log and the neutron-neutron log. Reference to the above-mentioned paper is suggested for detailed explanation of the method.

In the same paper were presented different applications of radiation logging in the oil fields and among those applications was discussed (at the conclusion of the paper) the quantitative evaluation of porosity of the formation, pointing out the limitations of the method available at that time.

Recently, and more especially in the course of the year 1953, excellent progress has been made in quantitative evaluation by developments and improvements of the neutron-neutron logging method. These new developments are the subject of this paper. To reveal the full importance of these new neutron-neutron developments, however, it is advisable to first view in perspective the capabilities and limitations of the other quantitative evaluating method available, the neutron-gamma method.

[1] "Radiation Logging and Its Application in the Oil Fields" by Paul Charrin and J. H. Russell. International Geological Congress, Algiers, Africa, September 1952. Reprints of this paper are available upon application to Perforating Guns Atlas Corporation, P. O. Box 1435, Houston, Texas.

**The Authors**

J. H. Russell

B. O. Bishop

James H. Russell is manager of operations of Perforating Guns Atlas Corporation. A graduate of A & I College, he is a registered professional engineer in Texas and holds membership in the American Petroleum Institute and several engineering societies. He spent two years with the research department of Shell Petroleum Corporation, developing geophysical apparatus for oil prospecting. Russell was director of radiation well logging with PGAC for five years, before being promoted to his present executive position.

Bryan O. Bishop is the neutron evaluation engineer with Perforating Guns Atlas Corporation. He received his degree as petroleum engineer from the University of Oklahoma, and then was field engineer with the North Basin Pools Engineering Committee. Later he was well supervisor with the Standard Oil Company of Texas before joining Perforating Guns Atlas Corporation.

## Neutron-Gamma Method

Until 1953 the only quantitative analysis that had been attempted was by the neutron-gamma method, which had its first application in 1942. This method involves the use of a radium-beryllium source situated in the logging tool below a small ionization chamber or geiger counter, which is capable, however, of detecting gamma rays only (See Fig. 1). The fast neutrons emitted by this source in traversing the formation are slowed down progressively until they reach an energy level at which they are captured by the formation. In the process of capture, secondary gamma rays are emitted and these are measured by the logging instrument.

As the slowing down process of the fast neutrons is proportional to the amount of hydrogen present in the formation, the secondary gamma radiation intensity resulting therefrom will reflect the amount of hydrogen in the formation. These secondary gamma rays cannot be measured at their point of origin. Only those that may reach the counter can be measured. Their chance of reaching the counter will depend, among other things, on two principal factors: One being the distance from the counter — as the radiation intensity is inversely proportional to the square of the distance from the source — and the other factor being the density of the rock, as the gamma radiations are directly attenuated by the density of the material traversed. These two factors account in large part for the flattening of the neutron-gamma response curve noted in porosity ranges greater than 16 to 20 per cent. This phenomena is illustrated in Fig. 2, which shows a neutron-gamma response curve and a neutron-neutron response curve taken from the same well. It will be noted that the deflection on the neutron-gamma curve remains about constant opposite porosities greater than 20 per cent.

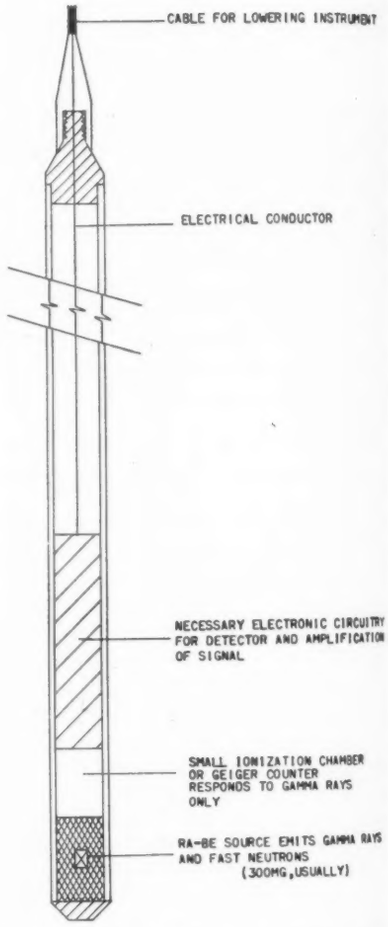
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**FIG. 1. Block diagram of sub-surface instrument components used in obtaining a neutron-gamma log.**

Because the gamma detecting instrument is recording gamma rays only, it is evident that any gamma radiation existing in the well will add to the gamma rays of capture to be measured

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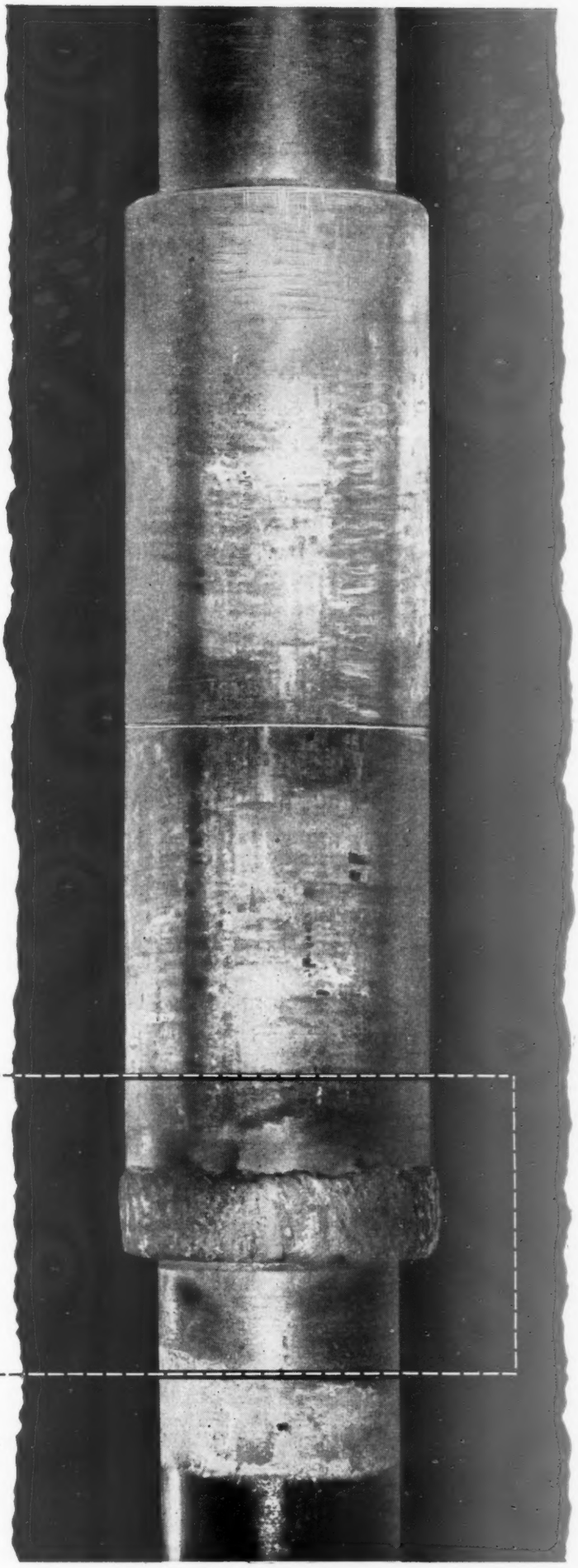

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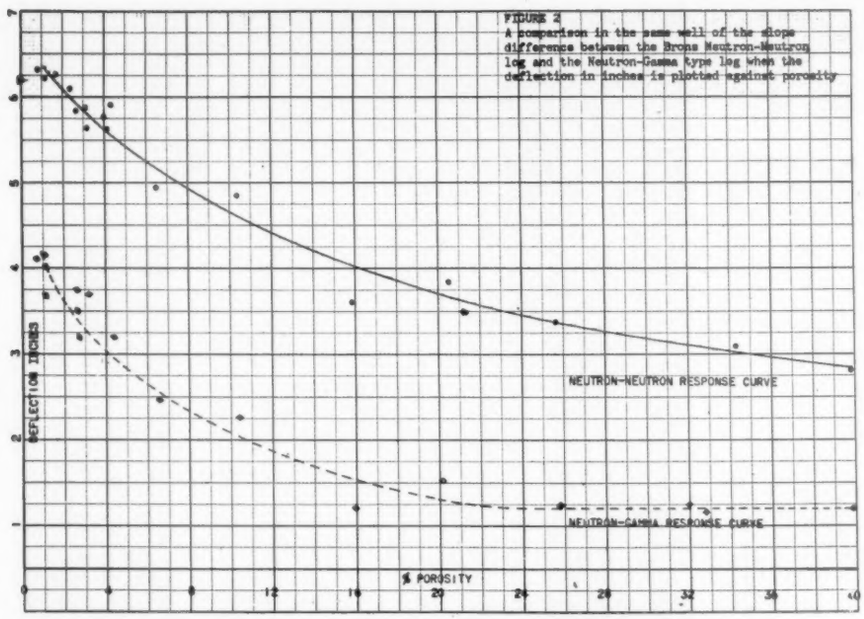
FIGURE 2
A comparison in the same well of the slope difference between the Brons Neutron-Neutron log and the Neutron-Gamma type log when the deflection in inches is plotted against porosity
NEUTRON-NEUTRON RESPONSE CURVE
NEUTRON-GAMMA RESPONSE CURVE
DEFLECTION INCHES
% POROSITY

**FIG. 2. A comparison in the same well of the slope difference between the Brons Neutron-Neutron log and the Neutron-Gamma type log when the deflection in inches is plotted against porosity.**

and, as a consequence, will erroneously affect the results. Among these unwanted gamma rays are those produced by certain strong, naturally radioactive formations penetrated by the bore hole. There are also gamma rays introduced by radioactive fluids or compounds that are sometimes added to the mud or to the cement. Accordingly, accurate evaluation of the porosity is difficult in such formations, as well as after the use of a radioactive compound in the well.

Another problem arises from the large amount of unwanted gamma rays emitted from the radium-beryllium source. It is estimated that approximately 10,000 gamma rays are radiated for every neutron emitted; and in spite of the elaborate shielding precautions taken in most of the instruments, a substantial number of these gamma rays reach the measuring instrument.

Quantitative evaluation of porosity by this neutron-gamma method has been done in recent years with some success. Papers presented, together with subsequent research and investigation, have pointed out the limitations to be expected. One of the earliest problems recognized was that of instrumentation. It was found that the logs obtained varied widely with the instruments used, the temperature of the well, the state of depletion of the battery supply, and the radiation strength of the neutron source. These are serious drawbacks for a precise porosity determination to be carried on from well to well and from field to field. It is therefore evident that the logs should depend neither on the instrument used, the strength of the source, nor the well conditions for uniformity.

Two logs run in identical formations and in identical wells should be alike. Their zeros should be the same and remain constant at all times. The amplitude of their log should be controlled only by the amount of hydrogen present in the formation — and not by an adjustment of the measuring tool.

The problem of making logs independent of the instrumentation in the neutron-gamma method is complicated by the fact that the complete instrument, with the neutron source in place, cannot be calibrated as a unit before it is run in the bore hole. The source has to be removed, and the tool is then calibrated at the surface with a small auxiliary gamma ray source. This procedure may introduce errors due to the respective intensities of the sources used and the geometry of the systems. Although these errors are usually small, the resultant of several errors may be considerable.

With further references to Fig. 2, the neutron-gamma curve in this well gives better results in quantitative attempts in the low porosity range (from 1 to 12 per cent) than it does in the high porosity range (12 to 40 per cent). This curve flattens rapidly as it approaches high porosity and for this reason the shale line is actually a greater range of porosities, all compressed. This indicates that it is doubtful that accurate quantitative work can be done by assuming some fictitious "shale value" porosity as is sometimes necessary, for instance, when no core analysis is available in the area.

Generally speaking, favorable results from other methods of quantitative evaluation have been limited in some areas. Results have been better in reef sections, and range downward to questionable in some sands.

## Brons-Neutron or Neutron-Neutron Method

The Brons-Neutron logging method was introduced commercially in 1950 by Perforating Guns Atlas Corporation, as a result of which a basically different and more simple approach to the problem of quantitatively evaluating fluid content or the porosity of a formation was made possible. During the past three years that neutron-neutron logging has been offered as a service, intense research and development have been underway with the object of rendering a more accurate and widespread application of quantitative evaluation.

This method also involves the use of a radium-beryllium source below a

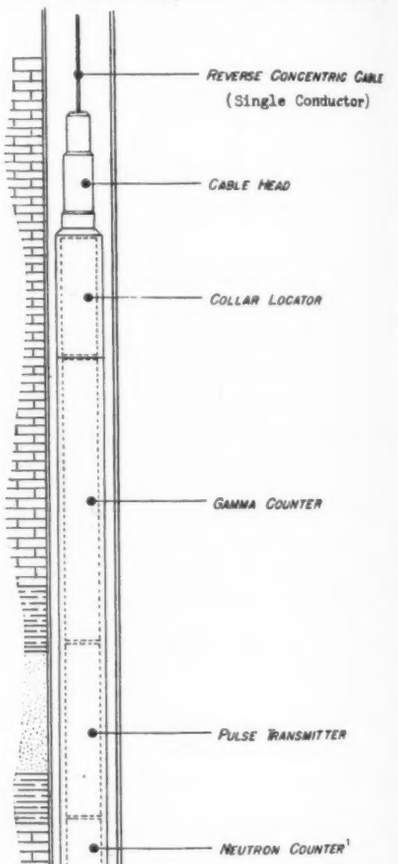


**FIG. 3. Layout of simultaneous gamma ray and Brons neutron-neutron sub-surface instrument. Total length of instrument — 10½ ft. OD of instrument 3⅝ in.**

*[1]3-in. in diameter and 3-in. long. Sensitive only to slow neutrons that are above thermal energy. Not sensitive to any gamma rays. [2]Emits gamma rays and fast neutrons. Source size usually 300 mg.*

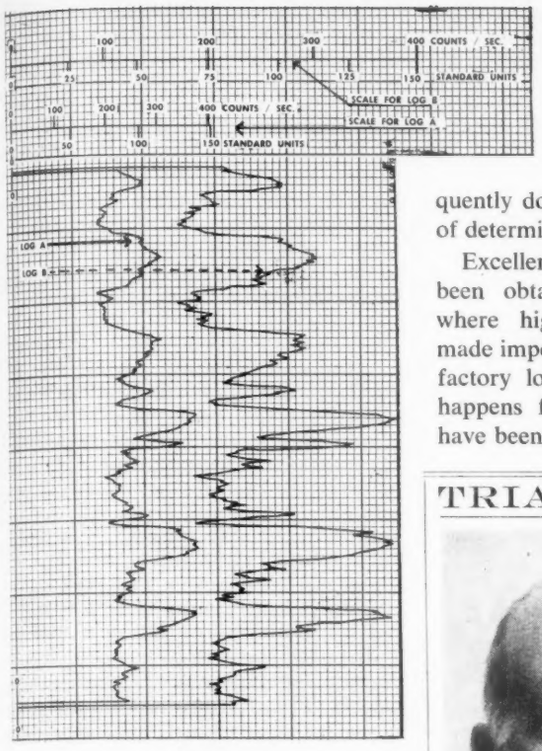


**FIG. 4. Shows applicability of Standard Unit Scale to log of any sensitivity.**

small counter-type slow neutron detector (See Fig. 3). This neutron detector is capable of detecting only slow neutrons. For the purpose of this paper, slow neutrons are defined as those neutrons that have left the source at high energy and have expended the greater part of that energy in traversing the formation, but still retain an energy appreciably above that of thermal neutrons. The quantity of these slow neutrons detected is inversely proportional to the amount of hydrogen present. It is interesting to note here that absolutely no secondary phenomena are recorded. On the contrary, the identical neutrons that originally were radiated from the source are recorded after being slowed down.

The simplicity of approach to quantitative evaluation by this neutron-neutron method is immediately apparent. Because the detector is sensitive only to slow neutrons, it will not be affected either by fast neutrons or by gamma rays of any sort. Only fast neutrons are radiated from the source. Even a large radium-beryllium source, the one used in logging, when brought right against this subsurface instrument, will not register. This feature — which is very important from an instrumentation point of view because it proves that no shielding from gamma rays is necessary — is even more important when it comes to the quantitative interpretation of the logs. In the neutron-neutron method, contrary to what happens in other methods, attenuation of the gamma rays due to the density of the formation is of no consequence. Even the fast neutrons that may pass directly from the source to the detector are not recorded and consequently do not enter into the problem of determining porosity.

Excellent neutron-neutron logs have been obtained consistently in wells where high gamma radiations had made impossible the recording of satisfactory logs by other methods. This happens frequently in oil wells that have been producing for a long period of time and in which radioactive salts have accumulated close to the perforations in the casing. Neutron-neutron logs have also been run after the use of radioactive compound in the well. The logs obtained before and after the use of radioactive compounds are invariably identical.

With the foregoing in mind, it is interesting to again examine Fig. 2, which shows a comparison in the same well of a neutron-neutron curve and a neutron-gamma curve. It may be observed that the slope on the neutron-neutron curve from this well is the more uniform. In particular it shows that for porosity range up to 30 to 40 per cent,

## TRIAD OIL CO. LTD. APPOINTMENTS

Hon. M. R. Bridgeman, C.B.E.

A. F. Down, O.B.E., M.C.

E. H. Tanner, President of Triad Oil Co. Ltd., announces the appointment of two additional directors, The Honourable M. R. Bridgeman, C.B.E., and A. F. Down, O.B.E., M. C. Both were nominated to the Triad Board by D'Arcy Exploration Company Limited, a wholly-owned subsidiary of Anglo-Iranian. D'Arcy Exploration recently made a substantial purchase of Triad shares.

Mr. Bridgeman, who is Managing-Director of D'Arcy Exploration, and Mr. Down were members of the party from Anglo-Iranian which visited Canada last August. Mr. Down will be Anglo-Iranian's resident representative in Canada.

Mr. Bridgeman joined Anglo-Iranian in 1926. During the war he was Petroleum Adviser to the Ministry of Economic Warfare in 1939 and was lent in the same capacity to the Government of India in 1942. From 1944 to 1946 he was Principal Assistant Secretary, Petroleum Division, Ministry of Fuel and Power.

Mr. Down joined Anglo-Iranian in 1938 after qualifying as a Chartered Accountant. He has worked at Haifa, Abadan, and in the Persian oilfields as well as at Anglo-Iranian's London headquarters. During the war, after serving in the Middle East and Italy, he was with the Canadian forces in Belgium, Holland and Germany, ending his war service as a Colonel on the staff of Canadian Army Headquarters.



To obtain more information on products advertised see page E-61

the curve is still sensitive, whereas the neutron-gamma response curve has flattened and at a much lower porosity. This high sensitivity of the neutron-neutron response curve for high porosity offers promise for more accurate quantitative work in highly porous sands.

### Instrumental Problems

Stable instrumentation is a prerequisite to dependable quantitative evaluation. Recent developments in the neutron-neutron instrument give this desired stability of performance by insuring consistent readings under adverse conditions and elimination of drift in the recorded curve.

The method of obtaining signal anomaly is simple. It involves the process of integrating the number of neutron counts detected against time. Even the relative size of one count (or electrical pulse) compared to another is unimportant. Only the amount in a unit of time is important.

The reliability of the method is such that a perfect log can be obtained even with a cable having poor insulation with a resistance of even as much as a few thousand ohms. The chances of a log being affected by a slight deterioration of the cable during logging and being unnoticed by the operator is thus removed, even in very deep wells where temperatures are high and high insulation is very difficult to maintain.

When the recording pen is set on the recording panel and the proper sensitivity of the instrument is selected, the log is recorded from the bottom of the well to the top, no matter how long it takes and no matter what the difference of temperature, and without any further adjustment of the controls. No drift is noted even in the deepest and hottest wells.

To maintain the performance of the instrument, frequent tests are made in the laboratory where instrument temperature is brought to 300 F. Wells with temperatures higher than 300 F are logged frequently. Figs. 4, 8, 9, and 10 (on which we shall elaborate later) show, among other things, the stability of the instruments and the repeatability of the curves.

When quantitative evaluation is made on a neutron log it is necessary that a definite zero or base line be given. With the neutron-neutron method it is possible to get an absolute zero with each log. This zero is easily obtainable and can be cross-checked in different ways at will. The recorded neutron-neutron curve being a linear function of the number of pulses counted against time, the absolute zero for the curve is the point of zero count. It is determined before logging is started and can be re-checked during the logging operation. One further proof of the absolute zero obtained with this log is the fact that any change in the sensitivity used on the instrument produces no change in the zero point.

The accurate calibration of any radiation instrument is absolutely indispensable for any quantitative interpretation to be made. Two logs run under identical conditions should be alike, even if made years apart, with different instruments, different sources, different sensitivity. This is not easy to accomplish if one takes into consideration the number of factors that can affect the reading. A small percentage of error on each of the components may lead to a total error incompatible with accurate measurements. The neutron sources, for example, are never alike in spite of the great care taken by the manufacturer. Experience has revealed differences between sources of more than 17 per cent.

Counters are manufactured and tested with the utmost care. They are as similar as possible, but they are not identical by any means. Constant improvements are made on the efficiency of the counters. During the last few years this efficiency has been raised several-fold. It is certain that this same trend will continue. A few years from now counters several times more efficient will be in use. It is obvious that


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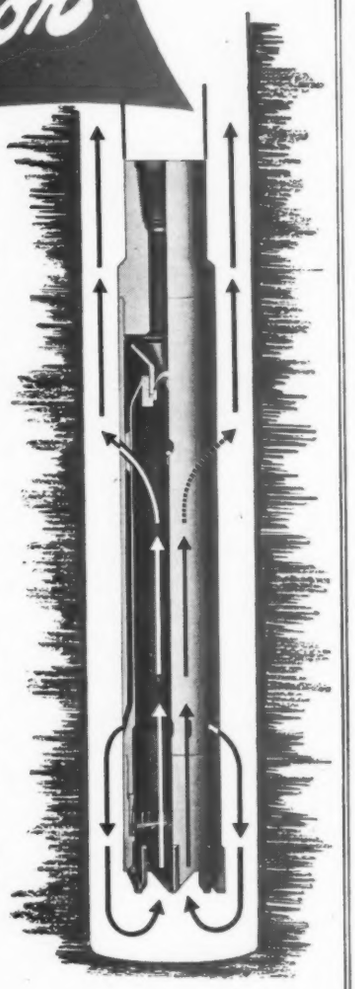

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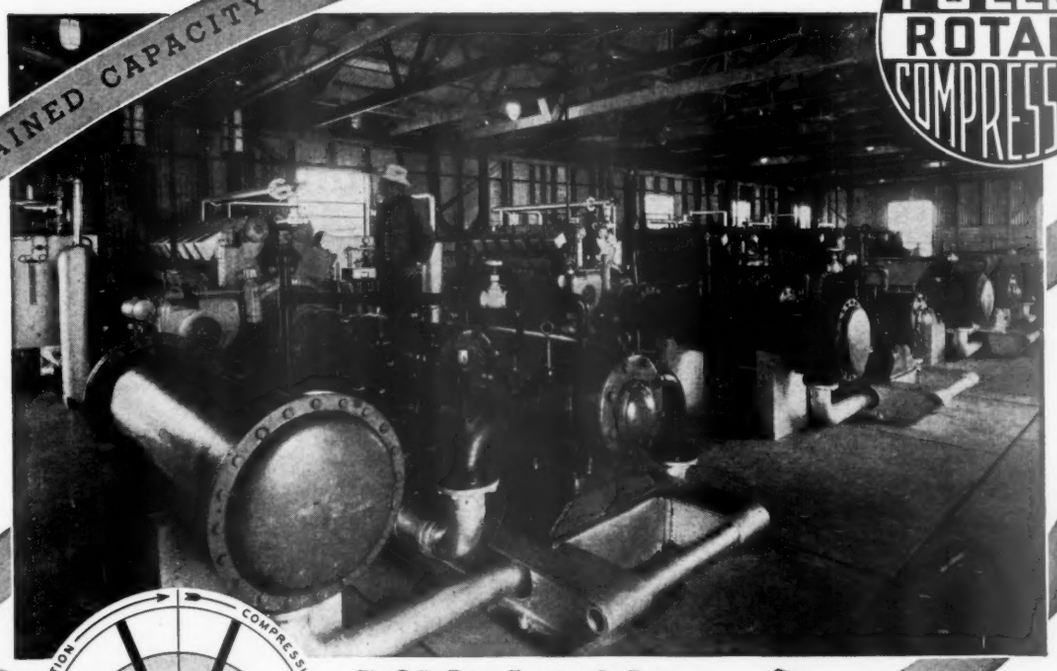

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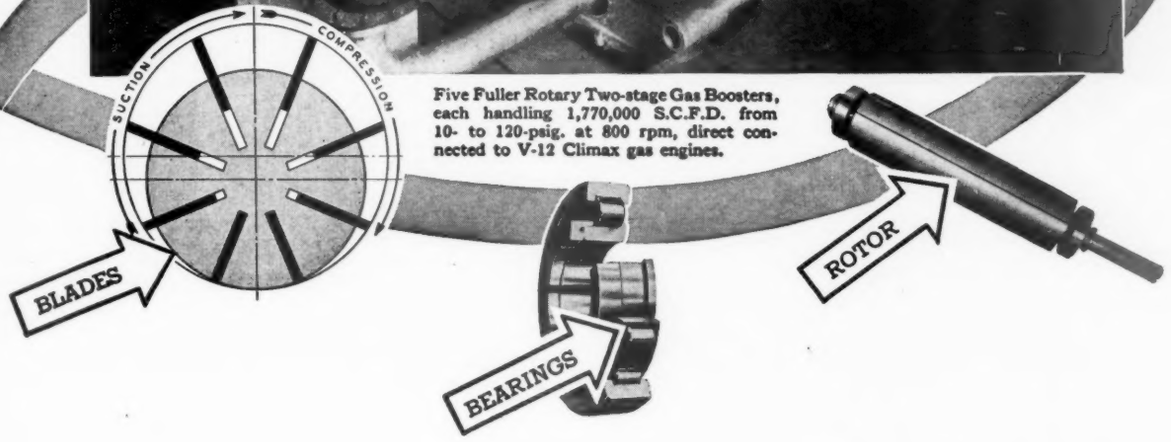

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it would be difficult to compare the logs recorded then with the logs being recorded now if the calibrations were not based upon one simple factor — an actual and definite quantity of that which we are seeking, namely, hydrogen. Therein lies the great value of this method.

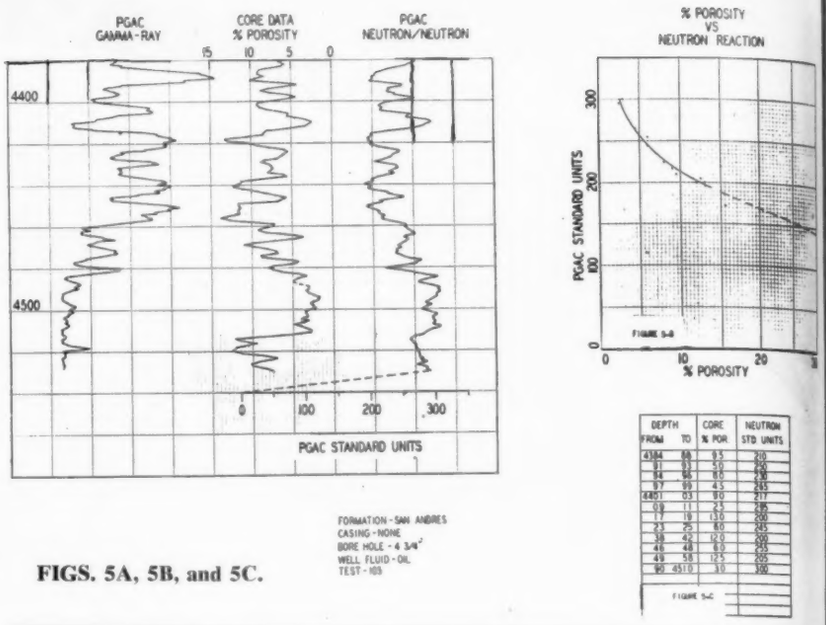
### New Method of Calibration

Physical dimensions of the various components of the subsurface instrument are maintained within quite close tolerances. Small differences, however, are inevitable and some substantially affect the performance. The electronic components in the subsurface and surface instruments are very stable and reliable; however, they are not absolutely perfect. Some small differences exist between every set. To eliminate the accumulation of all these errors a new and absolute method of calibration is used.

This new method was made possible by the exclusive features of the neutron-neutron logging system that uses a neutron counter that is not affected by the gamma rays from the source. The instrument is calibrated while completely assembled and in exactly the same condition as it is run into the well. The source is in place, connection to the cable is made, power supply is on, and the instrument is lying on a special rack made for convenience. The calibrator is a cylinder made of plastic, the chemical composition and physical dimensions of which were arrived at after long experimentation. When this calibrator is slipped over the instrument it places a pre-determined quantity of hydrogen immediately around both source and detector. This definite amount of hydrogen then becomes the standard reference for calibration. The measurements made reflect the direct effect of the hydrogen. Simple direct determination has an advantage over indirect calibration as shown below.

All calibrators are checked before being issued to field crews, and are rechecked frequently against a "reference standard calibrator." They all are calibrated to within less than one per cent. So far, none have shown any change in spite of being in use for over one year. This gives an excellent indication of their stability.

When the calibrator is slipped over the instrument, the recorder pen moves from zero to a certain deflection. This deflection, which we call arbitrarily "100 standard units," should be the same for all instruments if the sensitivity and all the components were always the same; but, as previously mentioned, they actually vary somewhat. The calibration is then obtained by changing the sensitivity until the correct deflection for 100 standard units is obtained. Both the zero and the deflection are re-




FIGS. 5A, 5B, and 5C.

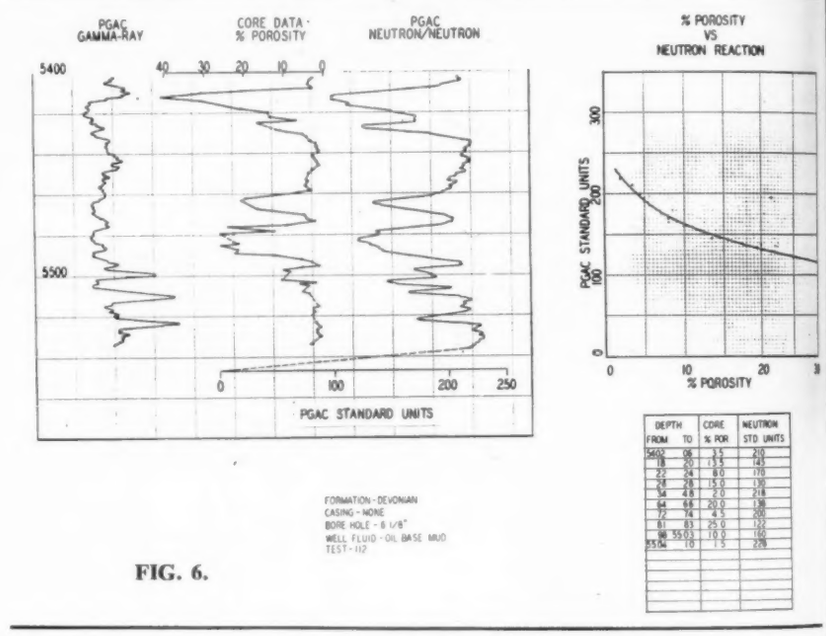



FIG. 6.

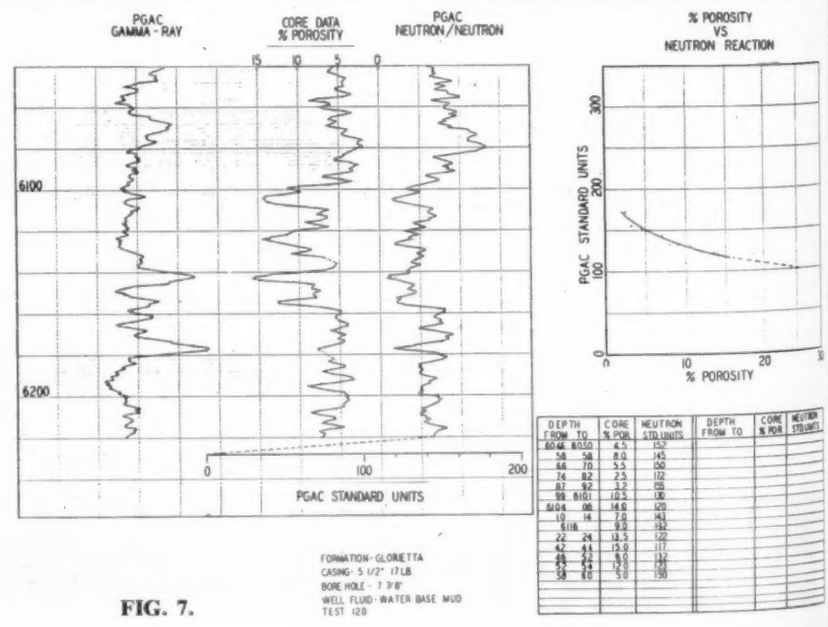



FIG. 7.

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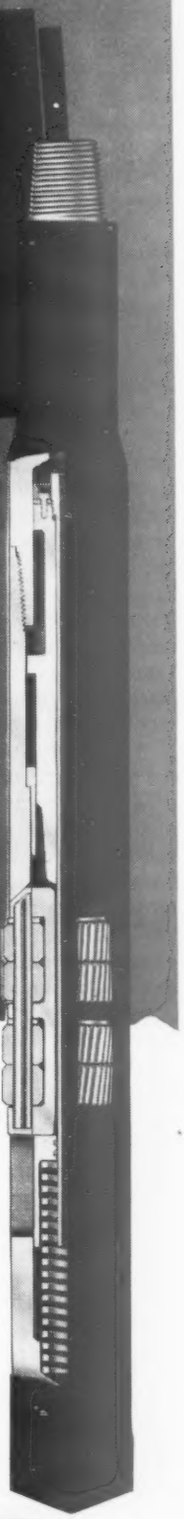

*Look at these figures...*

| SPECIFICATIONS OF 4 GRANT UNDERREAMER SIZES | | | | |
|---|---|---|---|---|
| Casing Size to Run In | 7" | 8⅝" | 9⅝" | 13⅜" |
| Body O.D. | 5¾" | 7¼" | 7¾" | 11½" |
| Maximum Underreaming Hole Dia. | 7¾" | 9¾" | 10⅝" | 15¼" |
| Cutters Collapse to | 6" | 7⅝" | 8½" | 12" |

**THEY ARE IMPORTANT TO YOU!** They show what *increased cutter expansion*, recently engineered into the Grant Rotary Underreamer, can do to vastly improve hole conditioning work on your wells...

**FIRST** – you get safe clearance between Underreamer body and casing because Cutters are collapsed to a sufficiently small diameter for running in.

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**THIRD** – you can run in and out of the shoe or a tight spot, collapsing cutters – or expanding them by pump pressure – as often as desired *without coming out of the hole.*

**AND FINALLY** – increased hole diameter with greater cutter expansion insures easier, faster and safer running and landing of casing and liners . . . provides for a thicker cement sheath for positive water shut-off . . . *in short, gives you better hole conditioning for a range of hole enlarging and well completion operations.*

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corded on the log and remain there as a permanent reference. As a double-check, after the log of the well has been run, the instrument is again calibrated at the surface as explained above. Any change in the zero setting or in the calibration will then be noticed and a control log re-run, if necessary. Experience has shown, however, that re-runs are seldom required.

Among other advantages of this "absolute type of calibration," we should mention the ease with which logs can be run at exactly the same scale, no matter what crew, what instrument, or what source is used. Fig. 10 is one of many examples noted. It shows four runs in a well, each run made with a different source. Each run called for a different sensitivity setting to bring it to standard calibration. One of the neutron sources used was more than 15 per cent lower in neutron radiation strength than the other three. The neutron zero position on each curve was identical. The order of repeatability, both quantitatively and graphically, speaks for itself. This figure is a reproduction of the actual record taken from the instrument truck's recorder.

Another feature of this calibration is the possibility for the operator to detect immediately any defect in the instrument. He knows that with a certain sensitivity setting he should obtain a known deflection for "100 standard units" when he sets the calibrator on the instrument. If he does not get this known deflection he knows that something is wrong. Then he immediately corrects the defect or changes instruments. This eliminates making a dry run but, more important, it eliminates the possibility of running an erroneous log. An instrument which does not perform properly and accurately, but which still performs, is very dangerous. It should not be run in a well, and the calibration precautions outlined above will prevent its use.

Fig. 4 shows logs run at two different sensitivities. The number of counts have been added to the calibration in standard units for illustration.

Figs. 8 and 9 illustrate the constancy of the neutron-neutron log when calibrated by this standard method. They show two neutron-neutron curves of the same section in the same well, using a different instrument for each curve. These logs were made under the control of a major oil company in one of their wells. Instrument No. 1 was calibrated at the surface to 3.0 in. neutron recorder deflection and at a panel setting of 75 on the sensitivity control. This instrument was then run into the well and a log obtained over the section. Without coming out of the well, the sensitivity control setting was doubled to 150 and a second log obtained over the section. Instrument No. 1 was then brought to the surface and calibrated. The calibration deflection at the 150 sensitivity control setting was found to be 6.0-in., or double the original deflection.

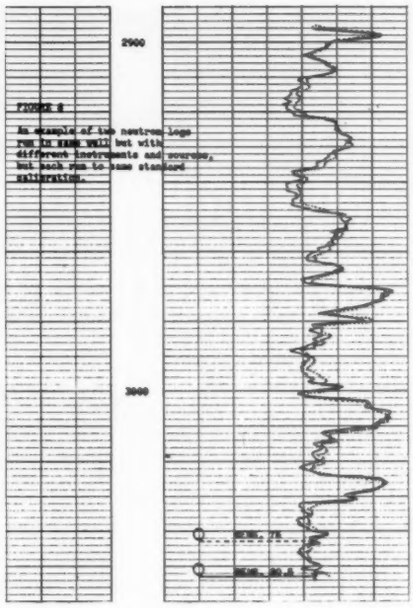


FIG. 8. An example of two neutron logs run in same well but with different instruments and sources, but each run to same standard calibration.

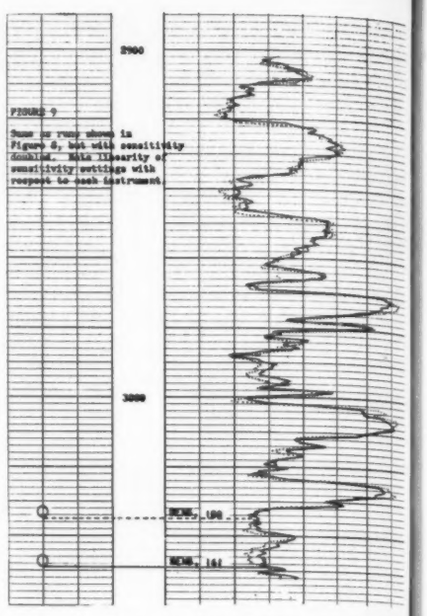


FIG. 9. Same as runs shown in Fig. 8, but with sensitivity doubled. Note linearity of sensitivity settings with respect to each instrument.

Instrument No. 2 was then calibrated to 6.0 in. deflection by use of the standard; and the sensitivity control setting necessary to obtain this 6.0-in. deflection was found to 161. At this setting a neutron-neutron log was obtained with Instrument No. 2 over the same section. Then, as before, without coming out of the well, the sensitivity was checked. This time, however, it was reduced to a one-half value, or 80.5 sensitivity control setting. Then the final, or fourth, neutron-neutron log was obtained of the section and Instrument No. 2 was brought to the surface and calibrated. The calibration deflection at 80.5 sensitivity control setting was found to be 3.0 in., or half of the third run deflection.

This bears out the linearity in the sensitivity control setting and calibration control setting. It also illustrates the fact that the standard calibrator is necessary for making proper sensitivity control settings in order to make both instruments react equally. The two neutron logs in Fig. 8 were obtained with the 3.0 in. calibration deflection and are shown with their zeros superimposed. Fig. 9 shows the two neutron logs obtained with 6.0 in. calibration deflection. These zeros also are superimposed.

### Application of Quantitative Evaluation

Because zones of porosity in lime and sandstone usually are fluid-bearing, a method of logging that will accurately detect and define these porous zones has a wide-spread application in the study of the reservoir. To develop this information, a combination of the gamma ray and neutron curves is necessary. The gamma ray curve defines the stratigraphic breaks in the section. Non-silty or non-shaly lime and sand record as low radioactivity. The neutron responds to the amount of hydrogen in the bore hole and within the formation. The amount of neutron response in shales depends largely upon lithography and the amount of overburden and compaction. Shales, because of their high water content, will cause the neutron curve to record high values.

The simultaneous recording of these two curves, as originally developed in 1950, is ideally suited for this type evaluation. By eliminating the possibility of measure difference between the two curves, greater accuracy can be obtained in differentiating between shaly zones and truly porous zones.

As said above, the logs are furnished with zero reference point and a scale in "standard units." Porosity values are then obtained from derived curves which are constructed from core analysis. It is necessary to construct a curve for each size of bore hole where the log is run in open hole and for each combination of casing and bore hole size when the log is made in a cased hole. Figs. 5, 6, and 7 show actual samples of how these curves are derived. The core porosity data is plotted on the same vertical scale as the neutron log and placed alongside for graphic correlation and to adjust for any depth discrepancies that might exist. The corresponding point values on each curve

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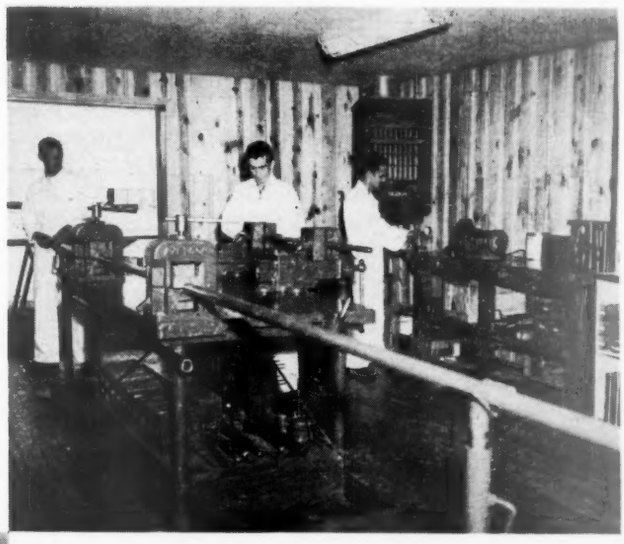

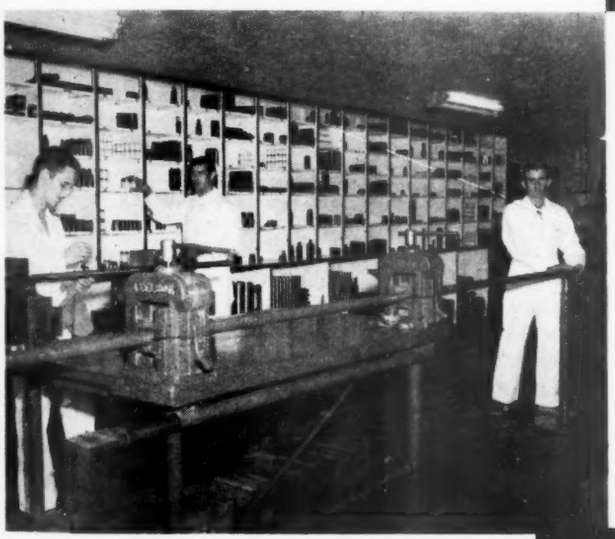

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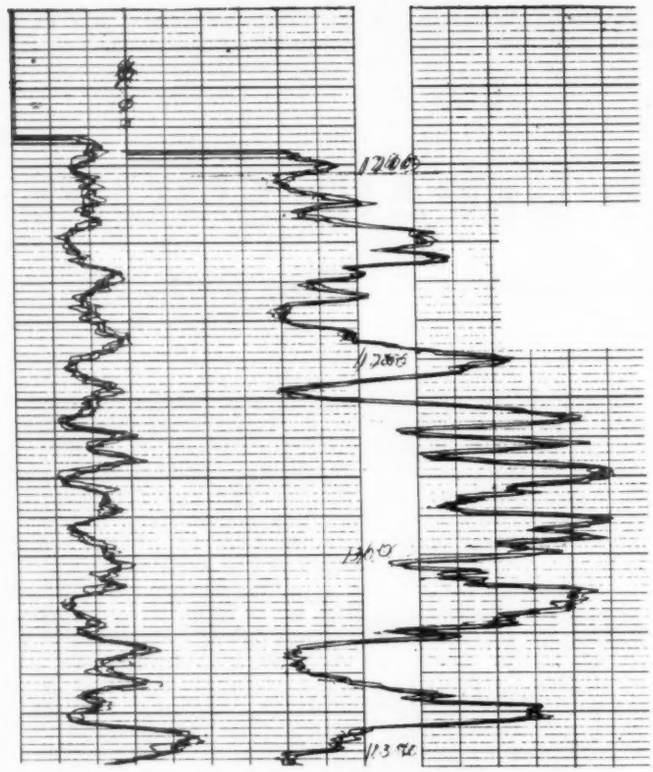

FIG. 10. This is an example of 4 runs superimposed. Each run was made with different radiation sources, but all were run to same calibration standard. Source strength in these tests varied as much as 17 per cent.

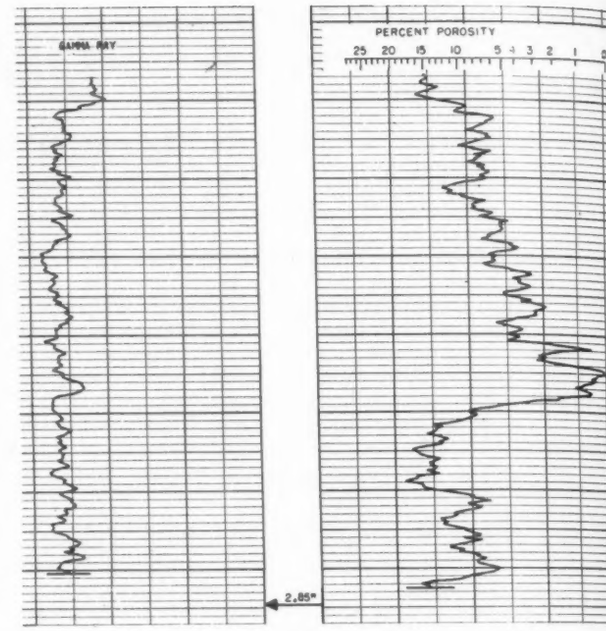


FIG. 11. Example of porosity scale derived from quantitative evaluation of neturon log
section average from neutron = 9.53%
Same section from core data = 9.8 %
This is typical of accuracy obtainable.

are then recorded as indicated in Fig. 5-C in the lower right-hand corner of each exhibit — core porosity in per cent, and equivalent neutron porosity in standard units.

After a series of these points are established, they are plotted on a linear graph chart (Fig. 5-B) as shown in the upper right-hand corner of each exhibit. Inspection of the black dots corresponding to each value shows the small amount of scattering evidenced when the curve is placed on the graph. Average porosities for a section may be determined by averaging the total neutron deflections at every one-foot or two-foot interval and converting inches of deflection to standard units and reading the porosity from the graph.

As the Brons neutron-neutron log registers all the hydrogen present, the curve of the log will shift to the left, or closer to zero, with increase in hole size. Casing, when set in the well, will cause the neutron log to shift even more to the left than the neutron log made in open hole before casing was set. This does not mean, however, that a marked casing shift to the left will always be noted at the casing shoe when going from the open hole up into the casing, because the amount of casing shift will depend upon the porosity of the formation at that point and the size of the bore hole below the casing. Normally, in wells with the open hole below the casing having a smaller diameter than the casing itself, the Brons neutron-neutron will shift farther to the left in the casing because the amount of well fluid surrounding the instrument is greater. The length of the shift at the casing shoe being the greatest in a zone of low porosity.

It is possible that if the casing is set through a zone of very low porosity, and the rat-holed section is highly porous, there may be a slight shift to the right or no noticeable shift. If the open hole below the casing is of the same size as the bore hole behind the casing, the Brons neutron-neutron will normally shift slightly to the left upon entering the casing.

### Determination of Porosity In a Well

Quantitative evaluation of the Brons neutron-neutron log has been in use since the early part of 1953. Since then, numerous wells have been logged and successfully evaluated. Calibration curves for various bore hole and casing sizes have been proved many times in wells scattered throughout the Permian Basin.

The following is an actual example (Fig. 11) and typical of the results obtained in porosity evaluations from the the neutron-neutron logging system. The well is in Lea County, New Mexico. Porosity evaluations from neutron-neutron logs were made in the Wolfcamp formation. The average porosity obtained was 9.53 per cent. The average porosity determined by core analysis was 9.8 per cent, which means a difference of only .27 per cent. It is to be noted that the core analysis was not available at the time the evaluation by the neutron-neutron log was made.

The work of quantitative evaluation is going ahead in different areas in the United States and Canada, but especially in the Permian Basin area of West Texas and New Mexico. More and more porosity versus neutron curves are being established for different physical conditions, such as various open hole sizes and various casing sizes; therefore, it is expected that better and better accuracy will be attained.

Due to the characteristics of the neutron-neutron log, it appears that quantitative evaluation of the porosities of the formations is consistent in large areas and consistent also from one formation to another, provided the physical conditions (hole size and casing) are the same. Therefore, from the data available at present, it appears that the Brons neutron-neutron method offers excellent promise for obtaining an absolute evaluation of the porosity of formations. * * *

*Drilling Mud*

# Measurement of Plastic Flow Properties

*New instrument reduces complexity of determining rheological characteristics of drilling fluids*

FRED CHISHOLM and SAM KOHEN

THE measurement of flow properties of plastic-type fluids is not new, but the application to drilling mud is new and is becoming increasingly important. The plastic flow characteristics of a clay-water suspension were first recognized by Bingham in 1916.[1] Ambrose and Loomis, in 1931 and 1932, were among the first to recognize the plastic flow properties of drilling fluids.[2] Since that time increased attention to these properties has occurred,[3,4] However, progress was retarded by the lack of a practical field instrument capable of making the necessary measurements accurately.

First attempts to measure the flow properties of plastic fluids were conducted in capillary tubes. Microscopical examination of the flow conditions in capillaries showed that plastic fluids do not duplicate the flow model of simple liquids.[5] Realizing the limitations of the capillary methods for measuring the flow properties, Reiner and Riwlin showed that the rotational viscometer should produce a consistency curve, the upper part of which must be linear for plastic fluids.[6] Little, if any, work was done for a number of years in developing a suitable field instrument. It was not until 1950 that Melrose and Lilienthal introduced a method of field measurement of mud flow properties.[7] They described a modified commercially available rotational viscometer that was capable of field analysis of the rheological properties of drilling mud. A Model 30 Fann V-G meter was converted by substituting a variable-speed governor unit for the normally supplied single-speed governor unit. This permitted rotational speeds of approximately 200, 300, 400, 500, and 600 rpm. The instrument did not receive wide field acceptance, however, because few field engineers were inclined to take the time to make the necessary plots and calculations required to determine plastic flow properties of mud.

Further development work by Savins and Roper[8] led to the design of a more practical field instrument. To eliminate the objectionable plotting of data, the new instrument constants were adjusted so that only two speed readings, together with very simple calculations, are required to determine the plastic flow properties of mud. To further simplify the operation, a torsion-spring assembly and dial indicator were substituted for weights suspended on a string, as previously required to obtain the null point. This development was released in February, 1953, to the Geophysical Machine Works who designed a unique gear-shift assembly to allow instrument readings to be taken at 300 and 600 rpm without the necessity of stopping the motor to shift gears. A positive speed indicating system was also included to assure accurate readings. The instrument identified as the Model 34 Fann V-G meter became available in May, 1953.

Various parts of the Model 34 Fann V-G meter are illustrated in Fig. 1. The instrument can be operated from any 6-volt power supply (storage battery or A-C transformer). With the gear shift in the down position, a rotational speed of 600 rpm. is obtained. For 300 rpm., the gear shift should be placed in the up position. The gears should be changed only while the motor is running. A neutral position for measuring gel strengths is between the 600 and 300-rpm. position of the gear shift. Adequate voltage supply is indicated by the blinker light, which burns brightly when the instrument rotational speed is being properly maintained, and goes out when the readings are unreliable. The procedure for measuring the plastic viscosity and yield value, the flow properties of a drilling mud, is:

1. **Place a recently agitated sample in a suitable container (an enameled, one-pint cup is satisfactory), and lower instrument head until the rotor sleeve is immersed exactly to the scribed line. With the gear shift in the 600-rpm position (down), press stirring switch for about 5 sec.**
2. **Wait for the dial reading to come to a steady value (time required depends upon sample characteristics), and record dial reading at the 600-rpm speed.**

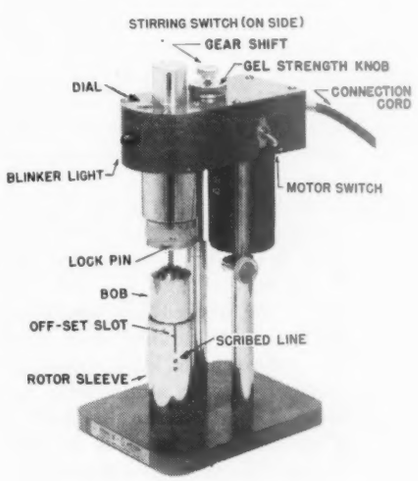


**FIG. 1. Model 34 Fann V-G meter.**

**EXCLUSIVE**

**The Authors**

Fred Chisholm

Sam Kohen

Fred Chisholm is chief chemist for Magnet Cove Barium Corporation. He was graduated from Hardin-Simmons University, and after teaching science in a West Texas high school for one year he became associated with Magnolia Petroleum Company in Beaumont, as a chemist. In 1944 he was employed by Magnet Cove at its Arkansas barite plant as chemist and metallurgist.

Sam Kohen is working in the field service laboratory of Magcobar in Houston. He was graduated from Rice Institute in 1941. He was associated with the Ordnance Department until 1944, at which time he joined the U. S. Naval Reserve. Following the war, he did graduate work at the University of Texas. In 1948, he worked as a field service engineer in Louisiana and Mississippi.

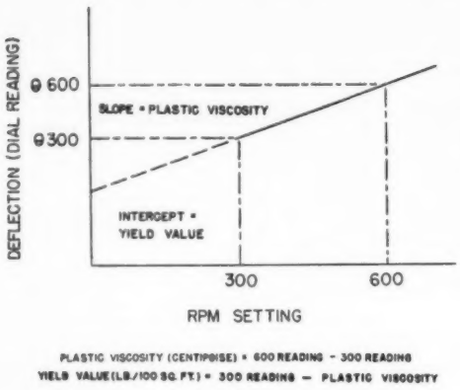


**FIG. 2. Typical flow curve of mud using the Model 34 Fann V-G meter.**

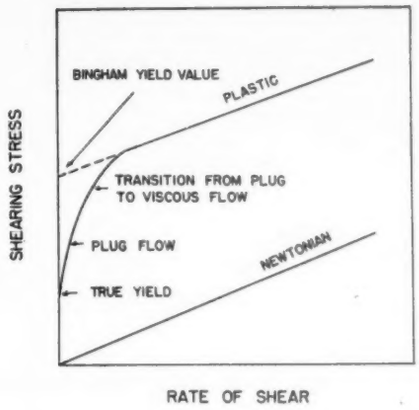


**FIG. 3. Flow diagram for Newtonian and plastic fluids.**

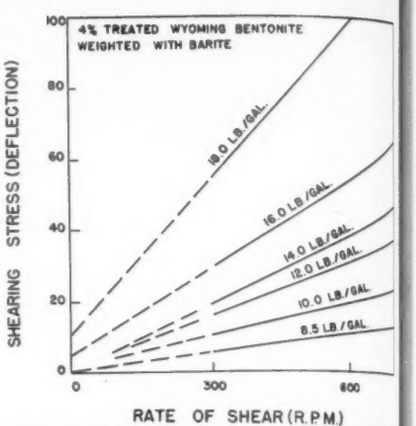


**FIG. 4. Effect of solids concentration on a typical flow curve.**

3. **Without stopping the motor, pull the gear shift all the way up (300 rpm), and wait for the dial reading to come to a steady value. Record this value as the 300-rpm reading.**

A typical flow curve for a drilling mud taken on the Model 34 Fann V-G meter is illustrated in Fig. 2. The slope of the straight line consistency curve is proportional to plastic viscosity, and the intercept is proportional to the yield value. The instrument constants have been adjusted so that plastic viscosity and yield value are obtained by using readings from only two rotor speeds of 300 and 600 rpm. Plastic viscosity in centipoises is equal to the 600 reading minus the 300 reading. The yield value in pounds per 100 sq ft is equal to the 300 reading minus the plastic viscosity.

In addition to determining the flow characteristics of drilling mud, other mud-test data can be obtained with the Model 34 Fann V-G meter. An apparent viscosity (viscosity in centipoises at 600 rpm) can be determined by dividing the 600 reading by two. This compares very favorably with readings obtained on the Model 30 Fann V-G meter, which actually gives results only 7 per cent higher, on the average, than the Model 34. Timed gel-strength measurements can also be made with the Model 34. The procedure for determining gel strengths is as follows:

1. **Stir at high speed for about 5 seconds, as done in measuring the flow properties.**
2. **Place the gear shift in the neutral position (between the 600 and 300-rpm setting), and turn off the motor.**
3. **Allow the desired rest time (immediate or 10 minute), then turn the gel-strength knob counterclockwise slowly and steadily by hand. The maximum dial deflection before gel break is the gel strength in either pounds per 100 sq ft or deflection units.**

The science related to the flow of fluids or mud is known as rheology. All fluids follow a definite flow pattern and some may be classified according to the two general consistency curves as shown in Fig. 3. Water, glycerin, and thin oil are examples of Newtonian or simple liquids, and a plot of the shear force exerted at different shear rates will produce a straight line consistency curve passing through the origin. If a similar plot is made using drilling muds, paints, or printing inks, a non-linear consistency curve that does not pass through the origin is formed. The phenomenon causing the intercept to occur at some point other than the origin is due to the minimum force required to start flow. As this force is increased, there is a transition from plug to viscous flow, up to the Bingham yield value. After the Bingham yield value is exceeded, equal increments of stress will produce equal increments of shear, and the system assumes the viscous flow pattern of a Newtonian fluid. Yield value and plastic viscosity are the terms used to characterize plastic flow.

It was Bingham's original concept that yield value resulted from friction between the clay particles.[1] He concluded that the friction exhibited between the particles of clay, in a clay-water system, resisted flow to the extent of the stress designated by the intercept. If friction were the only cause of yield value, a straight line consistency curve would be formed with a definite intercept on the stress axis.[9] However, a non-linear curve was formed and it was recognized that friction was not the only factor involved in producing the intercept. Flocculation can also create a force that tends to prevent flow.[9] The force of flocculation is the result of the attractive forces between the clay particles.[10] Strong forces of flocculation produce high yield values;[9] consequently yield value is one of the factors affecting the apparent viscosity of mud.

Mud is also composed of solids that contribute to apparent viscosity. By definition, plastic viscosity is the shearing stress in excess of yield value that will induce a unit rate of shear.[9] When the concentration of suspended matter is low, a fluid may exhibit no appreciable yield value and have only a low plastic viscosity. In a well-dispersed mud system, as the concentration of solids is increased, the plastic viscosity will increase, whereas the yield value will not show any appreciable change. Decreasing the diameter of these solids will increase the plastic viscosity as there is a net effect of increasing surface area, and, consequently, friction. The fluid-phase viscosity is also reflected in the plastic viscosity because plastic viscosity is analogous to the viscosity of Newtonian fluids.[9] Therefore, changes in the viscosity of the fluid phase will reflect changes in the plastic viscosity. For most practical purposes, however, plastic viscosity depends on the concentration of solids present and the size and shape of these solids.

Applying the concepts of rheology described above to drilling mud, it is reasonable to assume that plastic viscosity of such a system will depend primarily upon solids of the system, and the viscosity of the fluid phase. Yield value, on the other hand, is primarily caused by the attractive forces between the clay particles, and to a lesser extent by friction between the particles. A change in the plastic viscosity of a drilling mud will cause small changes in yield value. Yield value may be altered with little or no change in plastic viscosity. Water, then, may be expected to decrease the plastic viscosity, whereas the addition of a suitable chemical dispersant alone will decrease the yield value. Therefore, plastic viscosity and yield value as absolute flow properties will reflect the colloidal and surface-active behavior of solids present in drilling mud. Measurement of these properties should find application

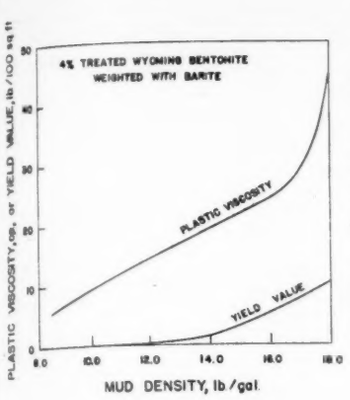


FIG. 5. Effect of solids increase on plastic flow properties of mud.

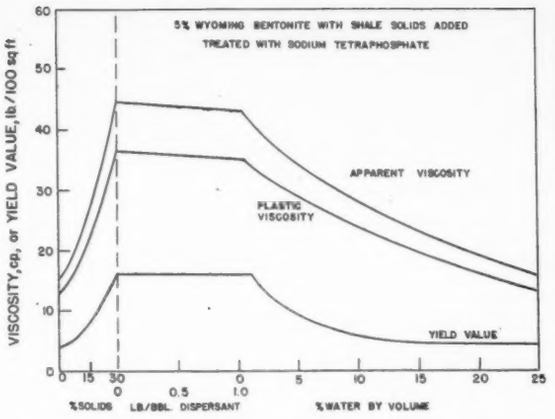


FIG. 6. Effect of solids and treatment on plastic flow properties of mud.

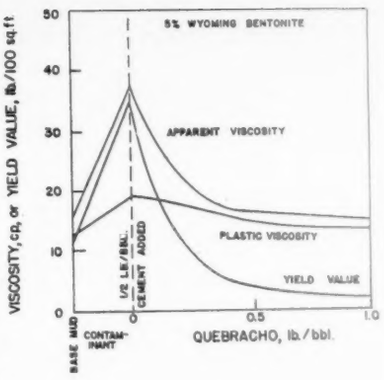


FIG. 7. Effect of contamination and chemical treatment on plastic flow properties of mud.

in developing a better understanding of such behavior, and in the treating of mud systems.

Present-day measurements of drilling mud properties in many instances include a "one-point" measurement of viscosity. In the case of a Newtonian fluid, a one-point viscosity is valid. As plastic fluids produce a non-linear consistency curve that does not pass through the origin, it should be evident that a single-point measurement cannot locate the position or direction of this curve. It is possible for two plastic fluids with entirely different consistency curves to have the same apparent viscosity, and only by evaluating the plastic flow properties could these fluids be distinguished rheologically. The Stormer viscosity, for example, is a function of both plastic viscosity and yield value, and will often be misleading when its application to mud control problems is attempted with no other information available.

Timed gel-strength measurements denote the thixotropic properties of the drilling mud, which are measurements of a condition at rest. On the other hand, plastic viscosity and yield value are flow properties and should not be confused with static measurements. Since both gel strength and yield value are functions of the force of flocculation, as yield value is decreased, the gel strength will usually decrease also; however, low yield value does not necessarily indicate a condition of 0-0 gels. Chemical dispersant may be required to accomplish a reduction in gel strength, but without any appreciable reduction in apparent viscosity.

It has been previously pointed out that the changes in the solids concentration of a system will appreciably affect plastic viscosity and cause only small changes in yield value. Using a 4 per cent Wyoming-bentonite suspension treated with caustic soda/quebracho, the plastic viscosity increased with increasing barite additions or solids concentration. The changes in plastic viscosity are shown by the increasing slope of the consistency curves as illustrated in Fig. 4. In Fig. 5 the same data are plotted in a different manner to illustrate actual changes in flow property values that occur when the weight of a 4-per cent bentonite suspension is increased with barite. Adding shale solids to a well-treated 5-per cent Wyoming bentonite suspension resulted in a sharp increase in both plastic viscosity and apparent viscosity, with relatively minor increase in yield value. As shown in Fig. 6, the addition of more chemical dispersant did not affect the flow properties; but the addition of water returned these properties to approximately that of the base mud. In both of these cases, apparent viscosity is primarily a function of plastic viscosity and not yield value, and may be controlled by the addition of water only.

As the attractive forces between clay particles are reduced through chemical treatment, yield value will decrease. Fig. 7 illustrates the effect of chemical treatment on yield value. An untreated 5-per cent Wyoming-bentonite suspension was contaminated with ½ lb per barrel cement. The apparent viscosity and yield value increased markedly with only a slight change in plastic viscosity. The addition of a chemical dispersant reduced the yield value and apparent viscosity without an appreciable change in plastic viscosity. In adding sodium tetraphosphate to an untreated 5½-per cent Wyoming bentonite suspension, the yield value was reduced, as shown by the change in the intercepts of the curves illustrated in Fig. 8. As there was no change in the slope of the consistency curve, the plastic viscosity was not affected by chemical treatment. Contrary to previous cases, the apparent viscosity is primarily a function of yield value and not plastic viscosity, and may be controlled by use of chemical dispersants only.

A study of a well drilled in Polk County, Texas, revealed a relationship between the apparent viscosity and plastic flow properties of the mud. As illustrated in Fig. 9, changes in the API funnel or apparent viscosities were accompanied by similar changes in either the yield value or plastic viscosity. This well used a low-lime low-alkalinity mud from 4500 ft to total depth. From approximately 6250 ft to 7600 ft, variations in the API funnel viscosity corresponded to similar variations in the yield value, with only minor changes occurring in either the plastic or apparent viscosity. Through this section, the chemical additions to the mud were increased to reach the minimum values illustrated. Water was added, but only in sufficient amount to maintain a control on plastic viscosity. Conversely, at approximately 11,200 ft an increase in mud density resulted in a very sharp increase in the funnel, apparent, and plastic viscosities. The yield value did not change appreciably, indicating a well-dispersed mud system. The addition of water, while maintaining the mud density, reduced the funnel, apparent, and plastic viscosities to reasonable values. Chemical treatment was maintained at the usual level during this time.

From a practical point of view it seems possible that certain operating limits may be established for the control of plastic viscosity at each mud density. Using the API funnel viscosity, together with other general mud characteristics, a plot of plastic viscosity at various mud weights was made using data recently obtained from a number of wells in the Texas Upper Gulf Coast region. The curves shown in Fig. 10 indicate possible upper and lower limits of plastic viscosity for satisfactory mud performance. Some points do not agree with the general trend, but the preponderance of satisfactory values occur between the two probable limits. By establishing proper operating limits on

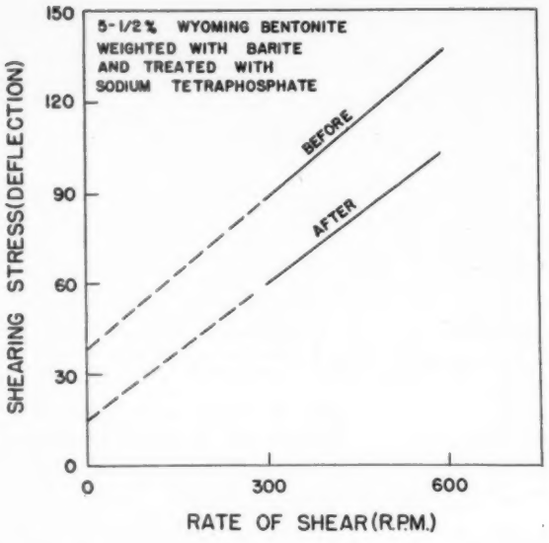


**FIG. 8. Effect of chemical treatment on typical flow curve of mud.**

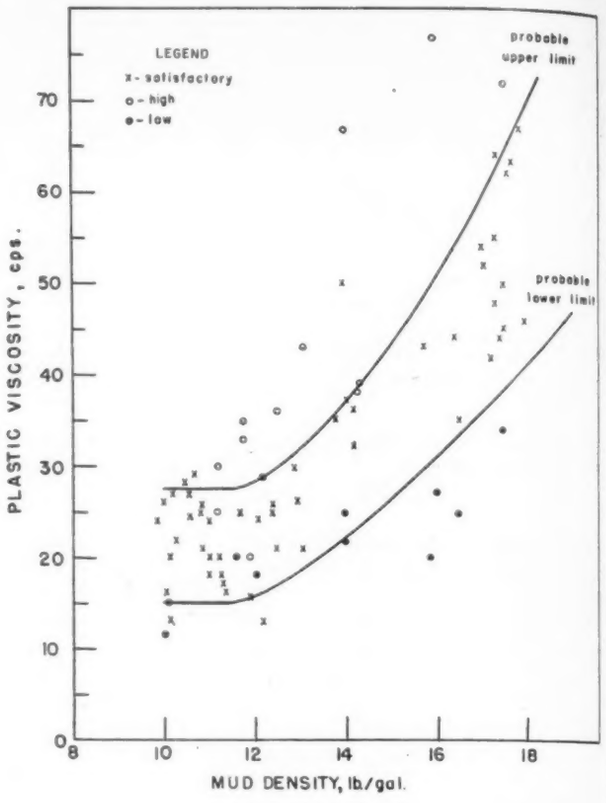


**FIG. 10. Field measurements of plastic viscosity at various mud densities.**

plastic viscosity, the effect of yield value, the other variable of apparent viscosity, can be quickly ascertained and proper chemical treatment undertaken if needed. Even though these limits are not considered to be rigid, it is felt that the use of such a chart may be of value in the proper control of drilling fluid.

In summary, it appears that the understanding and measurement of the plastic flow properties will permit a more direct treatment of the fluidity control of drilling muds. By determining a portion of the consistency curve of a mud through a two-point measurement using the Model 34 Fann V-G meter, the cause of variations in apparent viscosity can be determined and the proper treatment speedily and economically undertaken. As experience is gained, it will be found that certain minimum plastic viscosities and yield values are required for each mud weight to maintain a good drilling fluid. These flow properties can be of aid if continuous mud-testing data are taken and the trends of variation of each property observed. Like all mud control, the trends are more important than the absolute values.

In addition to applying these rheological properties to the control and treatment of drilling mud, they should also find application in the design of rig equipment and control of drilling procedures. Pressure variations in the hole that have resulted in lost circulation and blowouts when running drill pipe may be controlled by the proper application of safety techniques indicated by measurement of yield value and plastic viscosity. Some work has already been done in utilizing the plastic flow properties of mud in the design of casing float equipment to prevent lost circulation during the operation of running casing. Yield value and plastic viscosity are the absolute flow properties and are applicable in many situations involving drilling mud.

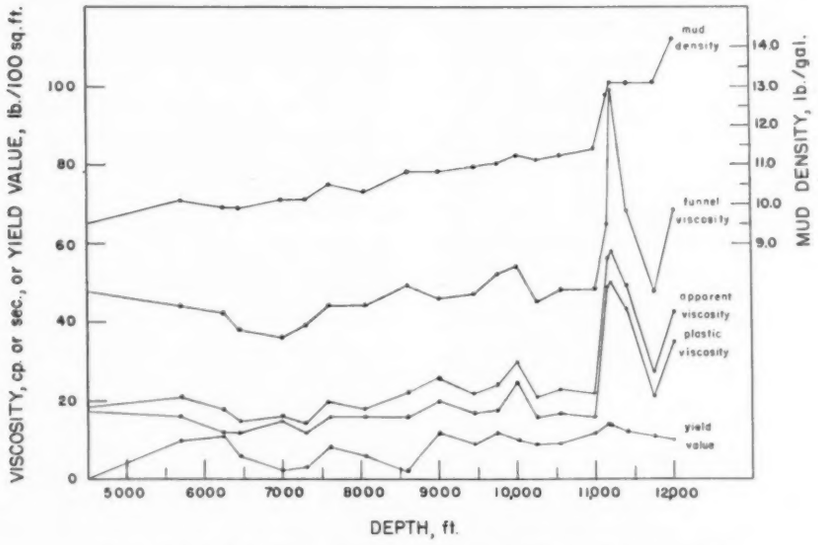


**FIG. 9. Well history showing mud and plastic flow properties.**

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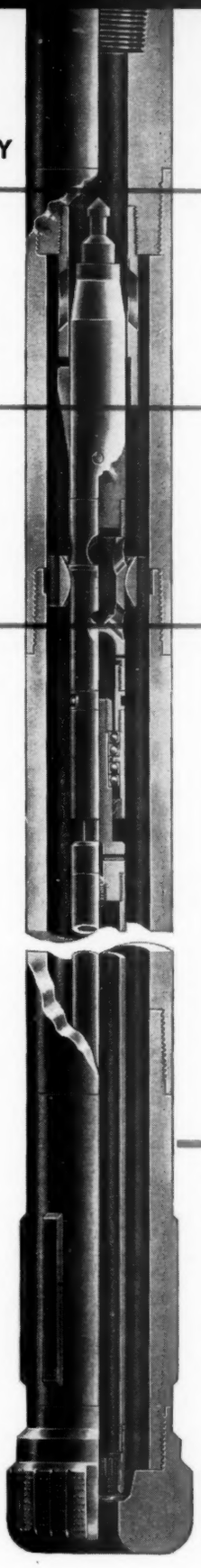

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**High injection operation under way. Two tanks on the left contain frac and flush oil. High visibility gages on each tank keep all operating personnel advised of progress of the job. Note complexity of suction hoses from the tanks to the mixing truck. This permits conduct of the entire operation with switching of only two valves.**

*In Spraberry*

# BIG FRAC RESTORES PRODUCTION

*High injection treatments have forced the redesign of conventional fracturing equipment to permit handling of large sand-oil volumes with minimum time loss and reduced operational hazards*

SIM H. CREWS*

RECENT months have seen the much maligned Spraberry receive two jolts that may restore in some small measure a part of the fervor with which it was acclaimed on discovery. At least a few operators now exhibit some cautious optimism, a few rigs are running, and the pipe lines are in business again.

Behind this upturn in activity are, among other things, the optional 80-160 acre spacing, the crude price rise, restoration of the field to production on completion of gas-handling facilities, increasing promise of the inhibition experiment, and perhaps most influential, the big-frac.

Pioneered by some astute and level-headed operators, the high volume fracturing of the Spraberry is the logical outcome of very practical planning. The early fracturing jobs of 1949 and 1950 saw some standardization of injection volumes at between 750 and 1000 gal of sand and jellied oil or other thickened carrying agent. Signal successes with these volumes prompted recommendations that they be doubled or, in some instances tripled, resulting in fracture operations of 2000 to 3000 gal. Close observation of the results achieved through the use of the higher volumes showed in many instances that initial production was increased, a more favorable PI obtained, and an appreciable improvement in sustained productive capacity was shown.

Applying these results to those obtained in the Spraberry, where the trend for the excellent IP's to fall rapidly with an accompanying and precipitous rise in gas-oil ratio was so disappointingly apparent, then was a logical action. And if 5000 gal could produce the beneficial effects observed in other fields, why not try 20,000 gal and see what would happen in the Spraberry. What did happen is of course history. Wells that had suffered production declines to practically stripper stage were revived to excellent commercial producers. Productivity indices were tripled or better. And, more important, re-fractured wells give some evidence of holding up better than after the original treatment. The final results from high volume fracturing will not be available for months to come. Initial results are so promising, however, that increasingly more operators are ordering them and the additional demand for equipment is forcing service companies to design and place in service equipment for which the demand was undreamed of a few months back.

One of these equipment items, a super sand-oil mixer, was placed in service only last month. Designed by Waldo Grossman, former Tide Water engineer and now assistant division manager for Halliburton in Midland, this mixer was constructed in Halliburton's Odessa shop under the supervision of Reg. Voss, shop foreman. The trailer-mounted mixer has only one power unit, a GM 471 diesel, driving

*Editor of Drilling and Producing.

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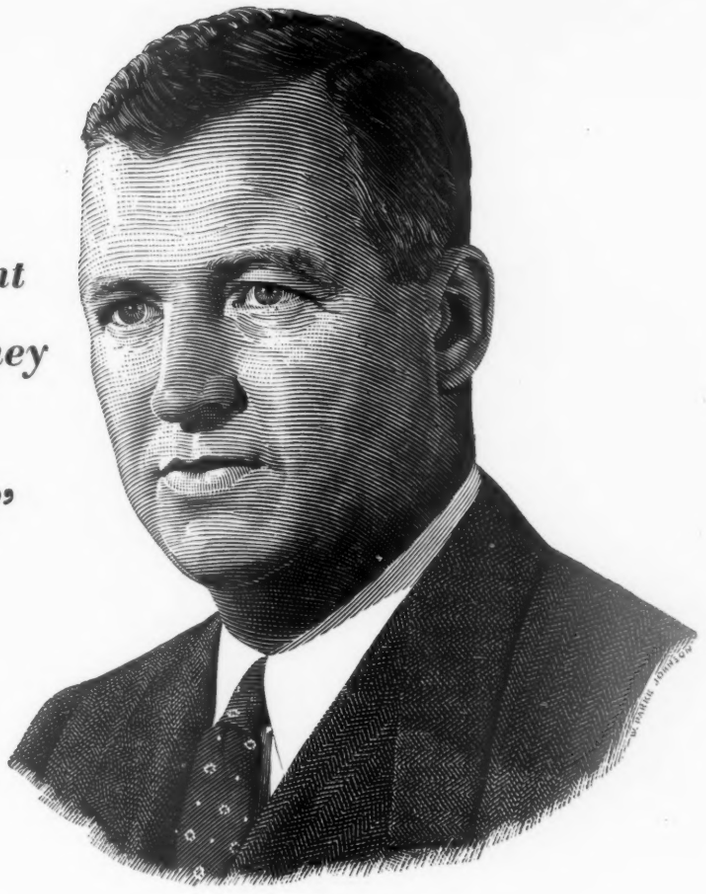

**MUNDY I. PEALE**
*President*
*Republic Aviation Corporation*

***"Wise public debt management with its goal of sound money is of prime concern to every American. Regular purchase of U. S. Savings Bonds contributes importantly to the achievement of this objective and, at the same time, helps assure our future security, individually and as a nation. We at Republic Aviation feel a deep sense of pride in the knowledge that 94% of all our employees became investors as a result of our most recent campaign and that $631,000 in bonds are purchased each month on our automatic Payroll Savings Plan."***

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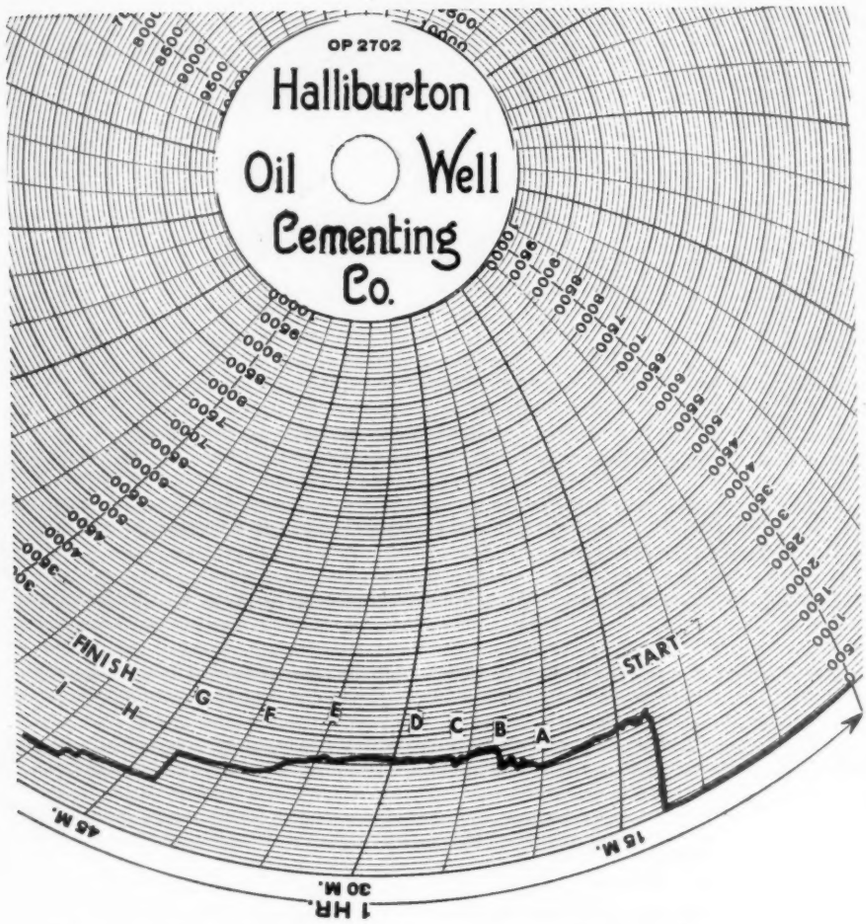



(A) Viscous fracture oil and sand at top of liner
(B) Fracture oil and sand at formation
(C) 30,000 lb sand mixed with 17,220 gal oil
(D) Switch tanks — start flush
(E) Fracture oil mixed with sand all in formation — flush oil at top of liner
(F) All fracture oil in formation
(G) End of high injection treatment
(H) Finish pump 40 bbl oil with one pump
(I) Final pressure

**Record of High Injection Treatment**

Well Data
8 ¼" salt string @ 4050 — 5½" liner 4000 to 7100
TD 7260 Open hole completion
Capacity 4000′ 8⅝ csg..... 244 Bbl
Capacity 3160′ 5½ csg..... 74 Bbl
318 Bbl total

Tank Gages

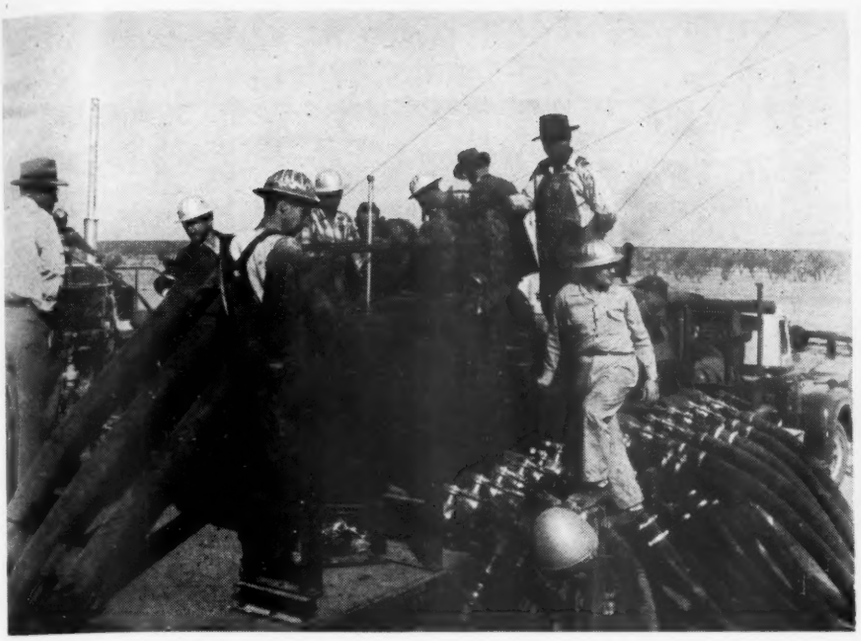
| Time min. | Spraberry crude | Fracturing oil | Bbl in well | Surface pressure | Pump rate oil, bbl/min. |
|---|---|---|---|---|---|
| 0 | 500 | 510 | 0 | 0 | 0 |
| 2 | 500 | 450 | 60 | 1700 | 30.0 |
| 4 | 500 | 390 | 120 | 1650 | 30.0 |
| 6 | 500 | 325 | 185 | 1600 | 32.5 |
| 8 | 500 | 260 | 250(A) | 1700 | 32.5 |
| 10 | 500 | 195 | 315(B) | 2000 | 32.5 |
| 12 | 500 | 130 | 380 | 2100 | 32.5 |
| 14 | 500 | 60[2] | 450 | 2100 | 35.0 |
| 16 | 470 | 20[2] | 520 | 2150 | 35.0 |
| 18 | 405 | | 585 | 2150 | 32.5 |
| 20 | 340 | Add Spraberry Crude to Tank | 650 | 2150 | 32.5 |
| 22 | 275 | | 715(C) | 2100 | 32.5 |
| 24 | 210 | 90 | 780 | 1900 | 32.5 |
| 26 | 140 | 90 | 850(D) | 1750 | 35.0 |
| 28 | 65 | 90 | 925 | 1700 | 37.5 |
| 30 | 20 | 60 | 1000 | 1700 | 37.5 |
| 31 | | 20[3] | 1040 | 1700 800[4] | 40.0 |

[1] end 13 min-30,000 # sand mixed w/17,220 gal Avg. 1.73 lb per gal.
[2] end 15 min-switch tanks.
[3] end 31 min-High Injection Pumping Completed.
[4] Final Pressure-Pumps stopped 800 psi.
[5] 30,000 # sand equals absolute volume of 32.2 bbl. This would increase volume of material handled during each of first 13 minutes by 2.48 bbl/min.

a jack shaft through a 2 to 1 reduction gear. Six 4-in. gear pumps for handling both fracture oil and flush oil are driven from this shaft through air clutches. The shaft also powers the three 6-in. screw type conveyors which lift the sand from the ground level hopper into the mixing tank. Each of the conveyors is equipped with a direct reading Veeder counter permitting the operator to know at all times the amount of

**Another view of the operation. Each of the trailer mounted cementing units has an individual suction line to the mixing tank that is equipped with 12 outlets. Elevation of the tank maintains a constantly flooded suction to each pump. Any difficulties from plugged suctions are thus confined to a single pump and adverse effects for the operation are minimized.**

**Sand (circled) entering mixing tank. Three screw type conveyors are capable of handling almost 7000 lb of sand a minute. Bulk cementer, left center, dumps sand into ground level hopper which loads conveyors. Variable speed controls permit selection of an almost limitless number of sand-oil ratios . Veeder counters measure sand.**



**Left, conveyors, mixing tank, and suction hose complex of high volume mixer. Rod projecting vertically from tank is liquid level gage. All pump truck operators can tell at a gance amount of sand-oil mix in tank.**

**Right, wellhead injection manifold. Provisions for the use of 12 pumps for fracturing are made, each pump having its own line to the manifold. A stoppage of one pump discharge then will not greatly affect the total operation.**

sand mixed. The jack shaft also drives a pump supplying power oil to a fluid motor. This motor drives a three-bladed, propeller-type, stirring device in the mixing tank, insuring that the attached pump trucks will at all times receive a uniform blend of sand and oil and reducing as much as possible the possibility of a "sand out," the fracturing equivalent of the jet aircraft's "flame-out," in which the well is plugged by a non-uniform sand concentration in the fracturing mix.

### High Volume Mixed

The six 4-in. gear pumps are each capable of delivering 11 bbl of oil a minute, having thus a combined capacity of 66 bbl per minute. The screw conveyors are capable of delivering 6930 lb (almost three and one one-half tons of sand a minute or at a rate of 2½ lb of sand per gallon of frac-oil. Connected to the jack shaft through two gear boxes and air clutches, the conveyors can be controlled to deliver sand in practically any conceivable ratio up to their capacity. As mentioned previously, they deliver from a ground hopper. This hopper is serviced by a bulk cement truck converted to sand service.

Sand and oil requirements for jobs completed to date have not approached the capacity of this equipment. Common pumping times for the 20,000 gal fracture jobs run from 13 to 17 min for the frac oil and sand and a like time for the flush. The design of this new equipment permits the completion of an entire fracture job with only two valves to switch, hence there is no lost time between the completion of the frac-oil pumping and the start of the flush oil pumping. Practical limits on injection rates are imposed by well conditions. Completions through 5½-in. casing permit pump rates of 35-40 bbl/min if surface pressures of 2000 to 2300 lb are permitted. If a well is completed through 7-in., rates of 50 to 55 bbl per minute may be achieved. Another common Spraberry combination, 8⅝-in. salt string and 5½-in. liner, will take 40 to 45 bbl per minute.

### Fracturing Oil

Present specifications require a special blend of refined oils as the sand carrying medium. Obtained from a nearby refinery, the blend is basically a topped crude, either Spraberry or Wilshire-Ellenberger, sweet and light green in color, reduced with refinery cut slightly heavier than diesel. This mixed product has a viscosity of 200 sec Saybolt at 120 F and an API gravity of approximately 25 deg. With the new mix truck, however, prospects are excellent that lease crude may be used for both fracturing and flushing and tests to ascertain the feasibility of this are underway. It may also be found that water, either salt or fresh, may be usable as the carrying medium if it is pretreated to inhibit emulsification. The advantages of using water in cost reduction and elimination of fire hazard are obvious.

### Further Tests Needed

Promising as the high volume fracturing of the Spraberry appears presently, only time can answer the question of its final benefit. It seems logical to acknowledge, however, that many jobs have already returned more than their cost, hence the immediate value of the job can hardly be denied. Its ultimate worth will depend, of course, on how well the formation lives up to its initial promise. * * *

## Pacific Coast Production Group to Meet

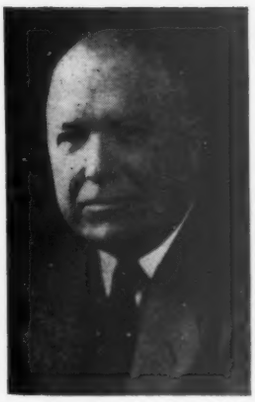
Program for the annual spring meeting of the Pacific Coast district of American Petroleum Institute, Division of Production, to be held in Los Angeles May 6-7 has been completed, C. F. Gates, General Petroleum Corporation, general chairman for the meeting, reported.

Feature of the drilling session will be a symposium on oil-well cementing and cementing practices. Papers to be given in production sessions will deal with field studies, secondary recovery practices, and corrosion.

Committee head for the drilling sessions program is J. K. Kellogg, K. L. Kellogg & Sons. Chairman of the production sessions committee is O. A. Graybeal, Sunray Oil. Milan G. Arthur, Union Oil of California, is 1954 chairman, Pacific Coast district.

E. O. Peschke of Baker Oil Tools is head of the general arrangements committee.

**The 1000th man** to register was Vincent Thomas, Texas Crude Oil Company, Fort Worth. Miss Virginia Ansley, Kingwood Oil, of Oklahoma City Desk and Derrick Club, tagged him.



Frank M. Porter

Jack Abernathy

Drew M. Young

**Speakers.** Frank M. Porter, president, American Petroleum Institute, gave the main address at the general session (See Page E-22). Jack Abernathy, Big Chief Drilling Company, Oklahoma City, and chairman of Mid-Continent District of API, gave welcoming address. Drew M. Young, Atlantic Refining Company, Dallas, Texas, spoke on "Supervisory Development on a Day-to-Day Basis."

# API District Meeting Has Record 1050 Present

AN expected 600 became 1050 persons actually registered at the spring meeting of the Mid-Continent District, American Petroleum Institute Division of Production, in Oklahoma City, March 17-19.

Besides those shown on the opposite page, committee chairmen of this very successful meeting were: Travis Phillips, Halliburton Oil Well Cementing Company, entertainment; R. B. McCloy, Decem Drilling Company, registration; Paul B. Strasbaugh, C. of C., housing, and Fred Fellingham, Stanolind Oil and Gas Co., publicity.

*(Pat. Pend.)*

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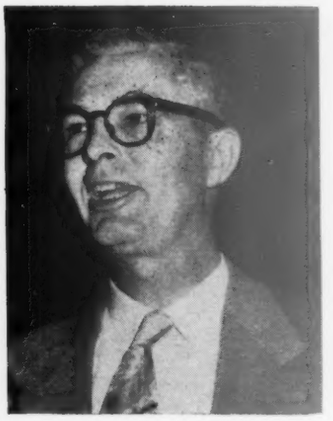
F. H. Willibrand

Dean A. McGee

Fred J. Neslage



H. B. Shelton

**Committee Chairman.** F. H. Willibrand of Sohio Petroleum Company, was chairman of general arrangements committee for the Oklahoma City meeting; Dean A. McGee, president of Kerr-McGee Oil Industries, Inc., was finance chairman; Fred J. Neslage of West Pampa Repressuring Association, was program chairman; H. B. Shelton, Sohio, was meeting room chairman.

## Three men who contributed to oil production methods are honored at well attended meeting held in Oklahoma City by Mid-Continent API

**"Citations for Service"** were presented by the district association to J. R. McWilliams, Tulsa (formerly with Skelly Oil Company and Carter Oil Company); Harold E. Berg, Tide Water Associated Oil Company, Tulsa, and R. W. Bond, Shell Oil Company, New York. The presentation was made by John G. Pew, Sun Oil Company and API vice president for production, standing at left.

### ANNUAL INDEX FOR 1953

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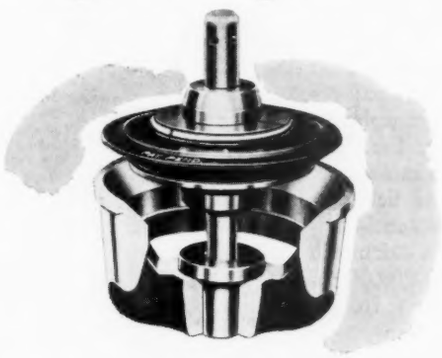

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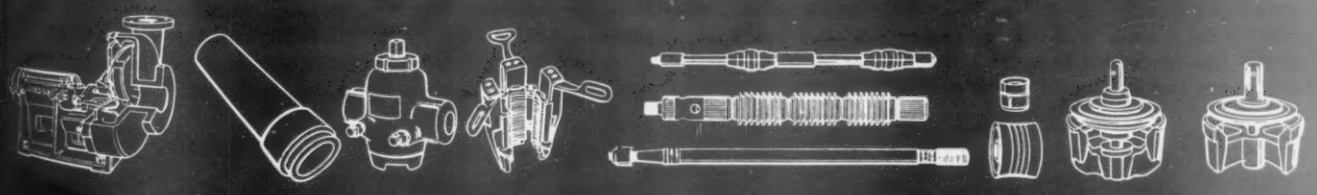

XUM

# WHAT'S DOING IN DRILLING

## LOUISIANA

★ With the completion of the 1-C State Lease 750, in Block 28, Kerr-McGee Oil Industries reports completion of its third gas-condensate well in Ship Shoal Block 28 field, in the Gulf of Mexico, off the coast of Terrebonne Parish. The well flowed 80 bbl of 40 degree gravity condensate and 6,640,000 cu ft of gas daily through a 20/64-in. choke from sand interval at 8604-28 ft, a new pay discovery.

★ With completion by Royalite Oil Company, Inc. of its 1 State Lease 2353, the multiple-pay Deep Lake gas-condensate field, in Cameron Parish, has added another producing zone. The well had a calculated open-flow potential of 18,000,000 cu ft of gas daily which flows from sand intervals at 9089-22 ft.

Through a 12/64-in. choke, on pre-potential tests, well flowed at the rate of 2,620,000 cu ft of gas and 129 bbl of 56 deg gravity condensate daily. Bottom-hole flowing pressure gaged 3970 psi.

## CANADA

★ Amerada Petroleum Corporation obtained the seventh D3 formation oil producer at Alberta's Sturgeon Lake oil field recently, when its Crown NO-O-F-9-31 well in the North Sturgeon pool topped at 8850 ft.

Test of 8852-74 ft gave a gas flow in 15 min at a rate not measured, followed by an oil flow in 46 min. The well flowed 46 bbl in 44 min through a ¼-in choke.

The latest well is three-quarters of a mile northwest of the discovery, which found 70 ft of productive reef. It is also a half mile SE of the producer Amerada Crown NO-O-F-33-6 well, which has productive reef measuring about 94 ft.

### SUMMARY OF DRILLING ACTIVITY FOR FEBRUARY

*(As compiled by Rinehart Oil News Staff)*

| States | New locations | | Wildcat completions | | | Field completions | | | Junked and abnd | | Temp abnd | | Abnd locs | | Current active wells | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | We | Field | Oil | Gas | Dry | Oil | Gas | Dry | We | Fld | We | Fld | We | Field | We | Field |
| Alabama | 7 | 1 | 0 | 0 | 4 | 1 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 7 | 1 |
| Arizona | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 |
| Arkansas | 8 | 47 | 0 | 0 | 11 | 41 | 1 | 7 | 0 | 1 | 0 | 0 | 1 | 0 | 6 | 24 |
| Canada (W.B.) | 4 | 33 | 4 | 0 | 8 | 17 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 1 | 10 | 30 |
| Colorado | 37 | 77 | 5 | 5 | 25 | 43 | 3 | 7 | 0 | 0 | 3 | 1 | 6 | 2 | 41 | 81 |
| Florida | 6 | 0 | 0 | 0 | 3 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 0 |
| Georgia | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 4 | 0 |
| Idaho | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Kansas | 62 | 276 | 8 | 0 | 37 | 134 | 15 | 78 | 0 | 0 | 0 | 0 | 1 | 2 | 55 | 131 |
| Louisiana | 29 | 240 | 2 | 1 | 24 | 101 | 25 | 39 | 0 | 2 | 1 | 8 | 3 | 19 | 47 | 154 |
| North | 11 | 127 | 1 | 0 | 9 | 62 | 10 | 11 | 0 | 0 | 1 | 2 | 3 | 2 | 10 | 42 |
| South | 18 | 113 | 1 | 1 | 15 | 39 | 15 | 28 | 0 | 2 | 0 | 6 | 0 | 17 | 37 | 112 |
| Mississippi | 8 | 26 | 0 | 0 | 10 | 11 | 3 | 4 | 0 | 0 | 1 | 0 | 0 | 2 | 7 | 17 |
| Montana | 4 | 12 | 1 | 0 | 11 | 36 | 2 | 13 | 0 | 0 | 1 | 0 | 1 | 1 | 18 | 30 |
| Eastern | 0 | 3 | 0 | 0 | 0 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 8 | 9 |
| Western | 4 | 9 | 1 | 0 | 11 | 33 | 2 | 13 | 0 | 0 | 1 | 0 | 1 | 1 | 10 | 11 |
| North Dakota | 5 | 11 | 0 | 0 | 3 | 10 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 15 | 18 |
| Nebraska | 9 | 20 | 1 | 0 | 9 | 8 | 3 | 9 | 0 | 0 | 0 | 0 | 0 | 0 | 7 | 17 |
| Nevada | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 5 | 0 |
| New Mexico | 13 | 85 | 2 | 1 | 16 | 29 | 20 | 3 | 0 | 1 | 2 | 1 | 1 | 3 | 58 | 128 |
| Eastern | 8 | 61 | 2 | 0 | 11 | 27 | 8 | 3 | 0 | 0 | 1 | 0 | 0 | 0 | 34 | 95 |
| San Juan | 5 | 24 | 0 | 1 | 5 | 2 | 12 | 0 | 0 | 1 | 1 | 1 | 1 | 3 | 24 | 33 |
| Oklahoma | 61 | 678 | 12 | 1 | 44 | 448 | 40 | 155 | 0 | 1 | 1 | 0 | 1 | 15 | 82 | 613 |
| South Dakota | 0 | 0 | 0 | 0 | 3 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 1 | 0 | 1 | 1 |
| Texas | 439 | 1231 | 53 | 20 | 279 | 633 | 114 | 209 | 0 | 0 | 9 | 10 | 13 | 49 | 418 | 1013 |
| East | 16 | 60 | 2 | 0 | 16 | 17 | 20 | 4 | 0 | 0 | 1 | 0 | 1 | 3 | 15 | 121 |
| Gulf Coast | 37 | 109 | 5 | 4 | 30 | 65 | 9 | 17 | 0 | 0 | 1 | 1 | 0 | 5 | 44 | 95 |
| North Texas | 101 | 315 | 12 | 1 | 49 | 139 | 3 | 52 | 0 | 0 | 1 | 0 | 1 | 6 | 53 | 120 |
| Panhandle | 11 | 85 | 0 | 0 | 5 | 31 | 28 | 6 | 0 | 0 | 0 | 1 | 0 | 0 | 19* | 32* |
| South Texas | 95 | 190 | 3 | 12 | 77 | 93 | 48 | 74 | 0 | 0 | 3 | 6 | 4 | 3 | 68 | 115 |
| Border | 24 | 81 | 3 | 0 | 13 | 43 | 0 | 11 | 0 | 0 | 1 | 0 | 1 | 0 | 26 | 71 |
| West Central | 80 | 120 | 15 | 1 | 45 | 57 | 3 | 26 | 0 | 0 | 0 | 0 | 4 | 4 | 57 | 49 |
| West Texas | 75 | 271 | 13 | 2 | 44 | 188 | 3 | 19 | 0 | 0 | 2 | 2 | 2 | 28 | 136 | 399 |
| Utah | 4 | 0 | 1 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 17 | 0 |
| Wyoming | 17 | 79 | 12 | 0 | 15 | 69 | 2 | 14 | 0 | 0 | 1 | 1 | 1 | 4 | 44 | 118 |
| Totals: Jan. | 699 | 2425 | 121 | 47 | 611 | 1780 | 254 | 584 | 6 | 5 | 10 | 21 | 17 | 144 | 808 | 2359 |
| Totals: Feb. | 713 | 2816 | 101 | 28 | 503 | 1583 | 228 | 542 | 0 | 5 | 21 | 22 | 29 | 98 | 845 | 2382 |
| 1954 Total: | 1412 | 5241 | 222 | 75 | 1114 | 3363 | 482 | 1126 | 6 | 10 | 31 | 43 | 46 | 242 | ... | .... |

*Figures Incomplete

### Rotary Rigs Operating in Oil Fields of United States and Canada*

| | Feb. 8 | Feb. 15 | Feb. 22 | March 1 | March 8 | March 15 |
|---|---|---|---|---|---|---|
| Pacific Coast | 152 | 147 | 143 | 144 | 155 | 155 |
| Oklahoma | 388 | 410 | 373 | 383 | 391 | 408 |
| Kansas | 146 | 148 | 150 | 145 | 169 | 161 |
| Rocky Mountains | 249 | 241 | 241 | 235 | 240 | 235 |
| Canada | 148 | 138 | 143 | 153 | 155 | 155 |
| Ark-La-Tex | 163 | 182 | 181 | 185 | 196 | 193 |
| West Texas and New Mexico | 455 | 456 | 451 | 508 | 481 | 503 |
| Gulf Coast | 508 | 517 | 517 | 508 | 505 | 503 |
| Illinois | 117 | 116 | 133 | 120 | 121 | 131 |
| North Texas | 326 | 331 | 329 | 315 | 310 | 313 |
| | 2652 | 2686 | 2661 | 2641 | 2723 | 2753 |

*As reported to the American Association of Oil Well Drilling Contractors by Hughes Tool Company.

**Scenes from Richfield CLA No. 67-29, deep producer in California's Kern County area. Casing run in this well was Spang Extreme line seven-inch in weights from 32 to 38 lb per foot. Power tongs and differential fill-up float equipment speeded the naturally fast running time for this type casing to almost 1200 ft per hour. With total weight of the casing string exceeding 600,000 lb, it was determined that safety requirements could be met by stringing 10 lines to the block and using 1⅜ in. lines.**

*Almost 3 miles* **DEEP** *in a Texas well*

# HIGH-PRESSURE CASING JOB "OK" WITH UNAFLO*

CEMENTING THEIR DEEPEST SINGLE STRING in the Gulf Coast area (7″ casing at 14,595′) on the McFaddin Trust No. 1 well near Port Arthur, Texas, the Magnolia Petroleum Company encountered hydrostatic pressure of 13,000 psi...bottom hole temperature 246°F. With an annular space of only 11/16″, Unaflo—the oil-well cement with the *retarded* set-stayed fluid and pumpable.

Magnolia used 325 sacks of Unaflo for this tough section of their deep well, and got a good job without a hitch. For the same reliable performance in your next well . . . be sure to specify Unaflo Oil-Well Cement. It protects your investment 3 ways:

**EASY PUMPING**—Unaflo's high initial fluidity makes pumping easier right from the start.

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**HARDENS NORMALLY** — Unaflo, after its retarded period, makes a strong tight seal, resistant to sulfate waters.

**SEND FOR FREE BULLETIN**—Gives latest authoritative tables of Unaflo performance. Write: Universal Atlas Cement Company (United States Steel Corporation Subsidiary), 100 Park Avenue, New York 17, N. Y.

Magnolia's McFaddin Trust No. 1 Block B in the heart of Texas' Gulf Coast oil fields near Port Arthur. Unaflo Oil Well Cement met problems of pressure, heat, small annular space.

*"UNAFLO" is the registered trade mark of the retarded oil-well cement manufactured by Universal Atlas Cement Company*

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**Unaflo *Retarded* Oil-Well Cement**
*Resistant to Sulfate Waters*
**Atlas Portland Cement—Type I**

**Atlas Portland Cement—Type II**
*Resistant to Sulfate Waters*
**Atlas High-Early Cement—Type III**

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### NEW MEXICO

★ One of the largest gas wells in the Mesa Verde field has been completed by Beaver Lodge Oil Corporation.

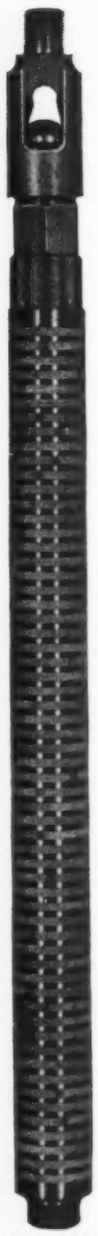
The well is Pubco Development, Inc., State No. 18, in San Juan County. On its first open flow potential test it flowed at a rate of about 30,000 cu ft of gas daily. The well came in without shooting, although it has always been customary to shoot Mesa Verde wells a heavy charge of nitroglycerine.

★ Amerada Petroleum Corporation 1-C Federal, midway between Lightcap and New Hope fields, rated a daily potential of 186 bbl of 45 deg oil, based on a 10-hour gage. Top of the Devonian was 9216 ft on elevation of 4474, and pay section was perforated between 9229-70 ft.

### COLORADO

★ Completion of a one-mile step-out northwest of the North Adena field in Morgan County, has been confirmed by Petroleum, Inc., Wichita. The company discovered the North Adena area last October and now has five wells producing and one drilling. Production is from the D and J sands at approximately 5600 ft.


# LOW COST PUMPING!



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5. Increases production in many cases.

**SAND FRAC**tured wells, for example, can be extra hard on ordinary pumps, but many Operators are finding it easy to handle the sand with Martin Plungers. They handle salt water, sand and any gravity of oil from any depth to 10,000 ft. more economically than any other equipment. They may be used in stroke-thru installations when necessary.

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### TEXAS

★ Skelly Oil Company has made a major discovery in Nolan County, Texas, opening first Cambrian production in the North Dora-Ellenberger pool with a well which flowed 73 bbl of 47 deg oil in an hour on a drill stem test between 5950-80 ft in Cambrian sand.

The discovery well penetrated 165 ft of Cambrian sand of which 125 ft is considered to be net pay above the water level.

★ Jake L. Hamon and associates, Dallas, were assured of a major extension to the multipay Bronco field of Yoakum County, West Texas, and Lea County, New Mexico, at their No. 1 Hendrick.

The well produced a total of 184.76 bbl of 46.3-gravity oil during a two-hour 10-minute drillstem test in the top of the Devonian at 11,745-785 ft. GOR was 247-1.

The well is approximately one mile south of the nearest completed well from the Devonian and is one mile south and ¼ mile east of Honolulu Oil Corporation's No. 1 Weems, the closest oil well, completed as a discovery from the Wolfcamp lime of the lower Permian.

★ Three new oil producers have been completed in West Texas.

Shell's No. 8 Phillips in the Howard-Glasscock field, Glasscock County, flowed 24 hours to make an initial production of 100 bbl of 31.8 gravity oil, plus 5 per cent water. Production is coming from the open hole between 2070-2357 ft.

Hanley Company completed its No. 1-B Cox in the Spraberry Trend area of Glasscock County. It flowed 177 bbl of 39.6-gravity oil in 24 hours through a 17/64-in. choke from the open hole between 6854-7799 ft.

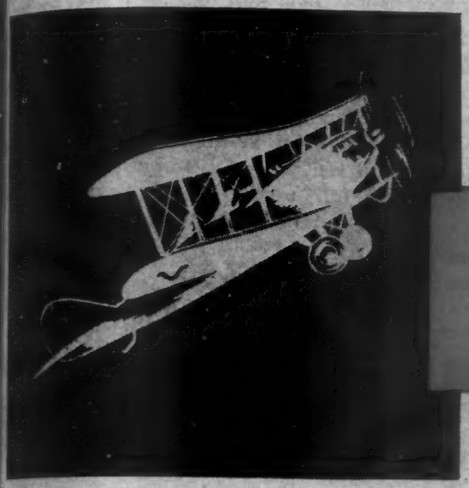
Magnolia Petroleum Company's No. 1 Brown and Altman has been completed in the Emperor Deep field of Winkler County, two and one-quarter miles south of Kermit. The well flowed 77 bbl of 35.6-gravity oil, plus 56 per cent water, in 24 hours through an open hole section between 3128-? ft.

★ Honolulu Oil Corporation has completed its No. 1-D J. E. Parker in the Parker (Wolfcamp) field, Andrews County. On a 24-hour test the well flowed 1029 bbl of 39-gravity oil and water. Completion was through a 1-in. choke and open hole was made at 8577-8620 ft.

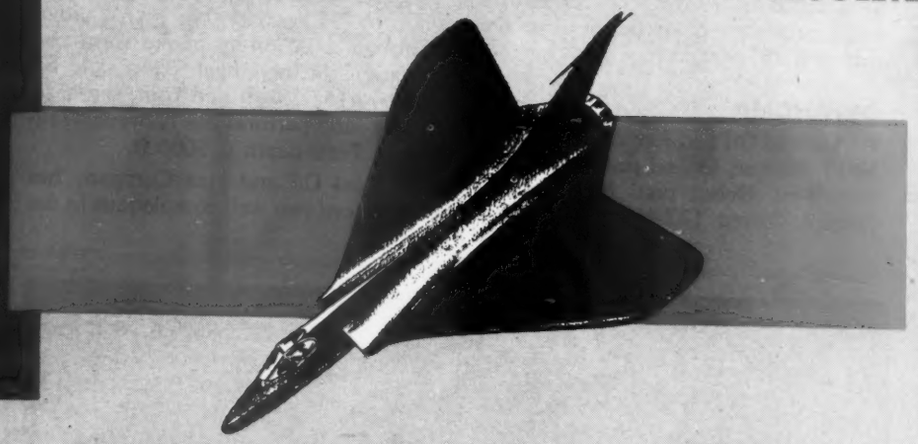
### CALIFORNIA

★ Two new oil wells, V.L. and W. No. 104 and Hartman No. 46, have been completed by Tide Water Associated Oil Company in its Ventura Avenue field, at Ventura. It is producing 695 bbl of 33 deg gravity oil daily and 396,-

# DON'T BUY AN OBSOLETE RIG!



A JAW CLUTCH TRANSMISSION RIG IS OBSOLETE



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000,000 cu ft of gas from the D-6 zone at a depth of 10,919 ft through a ½ in choke.

★ Hartman No. 46 is flowing 1186 bbl of 29 deg gravity oil daily through a 20/64 in. choke from the D-8 zone at a depth of 12,295 ft. Gas is also being produced from this well at the rate of 1,397,000 cu ft.

### OKLAHOMA

★ Ashland Oil and Refining Company No. 1 Walker, second producer in the new West Helsel pool in Cleveland County, flowed 177 bbl of oil in 24 hours through an 18/64-in. choke, after making 284 bbl in 15 hours through a 24/64-in. choke from open hole in the second Wilcox sand at 7008-10 ft.

★ Continental Oil Company No. 4 Ragsdale, Carter County, flowed 660 bbl of 37 gravity oil in 24 hours through a 20/64-in. choke from perforations in the Upper Tussy sand between 4157-208 ft and from the basal Tussy sand perforations between 4712-48 ft. Total depth is 5000 ft.

★ Signal Oil and Gas Company has announced two well completions in the Golden Trend area of Carter County, Oklahoma. The first of these, the No. 2 Herman Smith, is Signal's second well in the northwest extension of the Caddo field and was completed for a daly potential of 728 bbl per day flowing through a 24/64-in choke from the Hunton formation.

★ Signal also announced completion of its No. 1 Spears in Carter County. This well flowed 912 bbl of oil per day through a 20/64-in choke from the Sims sand of the Springer series.

### ILLINOIS

★ Sun Oil Company reports completion of its second well in the new Blackland pool of Macon county, Southern Illinois. The No. 1 M.H. Damery, on acid testing the Devonian from 1948-58 ft flowed 300 bbl in 12 hours and was choked to 50 bbl a day.

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CUT
SHOT HOLE
COSTS
U. S. Patents
2,615,684
2,666,622
Others Pending
"Bit costs are a mighty important item nowadays. We want a bit that will stay on bottom longer, making more hole per drill every day. And our company expects us to keep our bit costs down.
"When we find that a Hawthorne 'Blue Demon' can drill 90% of all formations faster than any other bit, at lower cost per foot, we're satisfied. Our company bit records show that they're happy too."
A "Blue Demon", with any thread connection to fit any pipe, and many sets of long lasting replaceable blades, can do the job of many, many drag and roller bits . . . for faster, cleaner, more economical hole.
Factory-controlled "on-the-drill" bit service saves you time and money too. Test and compare "Blue Demon" Bit service, and you'll standardize on "Blue Demons" too.
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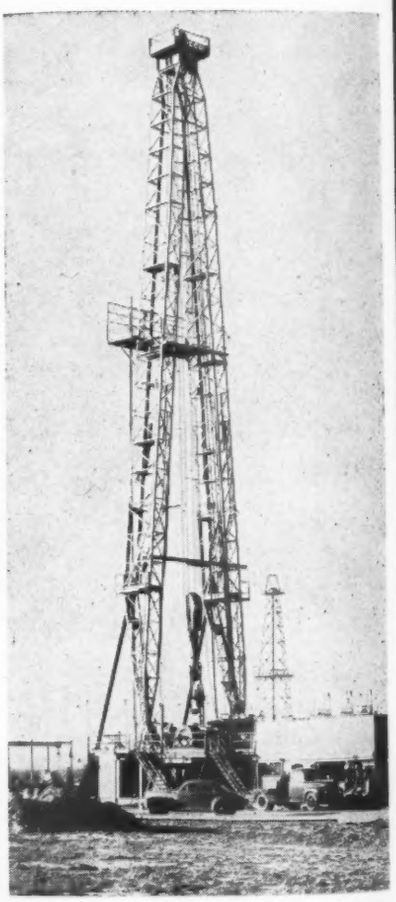
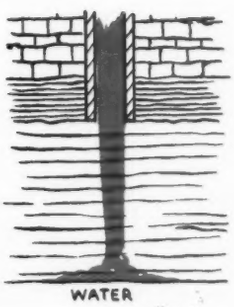
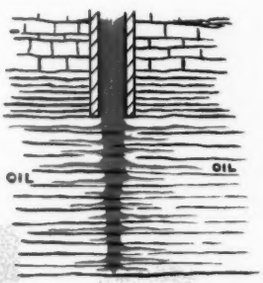


★ Richfield Oil Corporation's newest drilling rig, capable of drilling to 15,000 ft, began on its first hole recently in North Coles Levee near Bakersfield, California. The rig is powered by 18 diesel engines in single and multiple units, representing a total of approximately 3200 rated or 2800 continuous horsepower. Most of the engines have torque converted drives. Lawless Brothers, of Bakersfield, assisted Richfield engineers in working out the rig's power requirements.

# Block off water and acidize your pay with* PPA



**PPA THICKENS**
to a viscous temporary blocking agent when it comes in contact with formation water.




**PPA THINS**
to a retarded, high-penetrating acid when it meets oil . . . tunnels deeper into formation to direct live acid into virgin pay.

**WESTERN PPA,** an acid-in-oil emulsion, lessens the attraction between acid and formation water . . . blocks the water zone. PPA greatly increases the likelihood of acidizing the oil zone in wells producing dangerously close to water table or making some water. With oil zone penetration established by PPA, conventional acid is directed into the pay . . . increases your production. WESTERN PPA . . . another product of WESTERN RESEARCH.

*PREFERENTIAL PENETRATING ACID

**Engineered Well Services**

- Acidizing
- Fracturizing
- Perforating Jet and Bullet
- Gammatron Radioactivity Well Logging

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GENERAL OFFICES
MIDLAND, TEXAS

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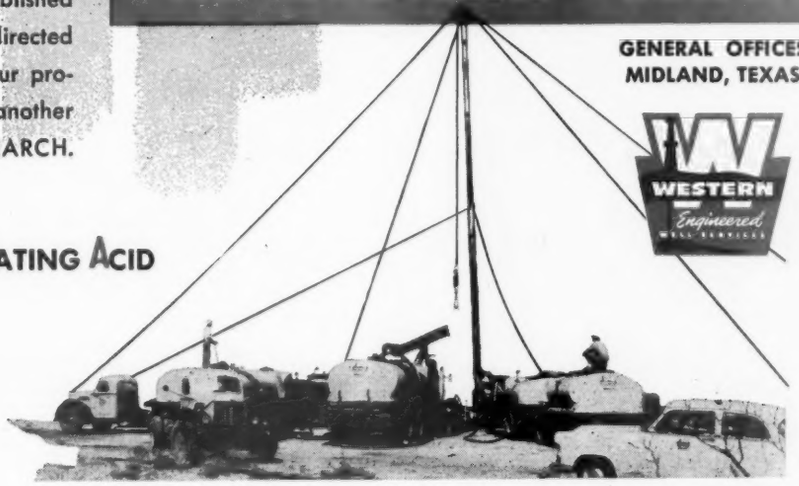




To obtain more information on products advertised see page E-61



XUM

# EXPLORATION ACTIVITIES

## KANSAS

★ A. G. Hill of Tulsa appears to have a Simpson discovery at No. 1 Dodson, one and one-half miles north of the Chance field in Pratt County. The Simpson was topped at 4414 ft and a 90-min drillstem test at 4415-28 ft recovered 80 ft of heavy oil-cut mud, 120 ft of muddy oil, and 175 ft of clean oil, with bottomhole pressure of 1410 lb.

A 90-min test at 4428-56 ft in the Simpson recovered 68 ft of muddy oil and 150 ft of clean oil. The Simpson will be tested after tools reach the Arbuckle.

★ Beardmore Drilling Company is setting up pumping equipment at No. 1 Berg, Harper County. Wildcat well is situated 12 miles southwest of Grabs pool and 5 miles southwest of Harper in the central part of the county.

From perforations in the Viola lime at 4758-64 ft the discovery swabbed 9 bbl of oil per hour after 10 hours.

## OKLAHOMA

★ Falcon Seaboard Drilling Company, of Tulsa, opened an important new producing area at a rank wildcat three miles northwest of the county seat city of Sayre and eight miles northeast of the Erick gas field in Beckham County. Good shows were encountered on a 135-min. drillstem test at No. 1 Murphy. Zone at 11,074-94 ft was tested, using a 3250-ft water cushion.

Water load began flowing in 65 min and gas surfaced in 75 min, estimated at 5,000,000 cu ft per day.

★ One of the most important oil developments in Oklahoma in months is the discovery of an oil and gas pool in Beckham County, more than 12 miles west of the prolific Elk City field, by Falcon Seaboard Drilling Company and Leo Sanders. Their No. 1 Murphy on a drill stem test between 10,074-94 ft in Granite Wash and Conglomerate, with tool open two hours and 15 min, flowed water cushion of 3250 ft and flowed gas at a rate of between 3 and 4000 cu ft a day with 58 deg distillate.

## AFRICAN JUNGLE SURVEY

★ More than $250,000 worth of geophysical equipment and supplies belonging to Rogers Geophysical Company was loaded on the freighter SS Borneo at the Port of Houston docks a short time ago and sent on its way to Mogadiscio, Italian Somaliland. The equipment will be used by Rogers in making geophysical surveys in an area of about 20,000 sq miles in the East African jungle.

A Rogers crew of 15 men will fly to Africa in time for the arrival of the equipment. About 40 natives will be employed in Somaliland to make the trip with the crew.

Closest civilization to the survey area will be about 350 miles away.

Russell Talty will be supervisor of the project, with Henry Guthormson as party chief. Other crew members include Charles Hodde, Benny Walthall, Owen Brown, Oscar Lewis, L. R. Book, John Stewart, J. Y. Keane, Ray Williams, David Hyatt, Henry Berger, Richard Baggett, Jesse Cornett, and John Robbins.

## CALIFORNIA

★ With completion of Pacific Western Oil Corporation's wildcat, 1 mile west of Belgian Anticline, westside San Joaquin Valley will have a new oil discovery. At last reports the test, No. 1 R-K, was in process of completion, after setting 7-in. casing at 5852 ft.

The wildcat reportedly flowed 28.5-gravity crude at a 400 bbl a day rate on a formation test at 5688-5852 ft. Production was from the third Point of Rocks sand (Eocene).

★ In the West Edison area of Kern County, Dumm Brothers Petroleum Corporation has completed a new pool discovery, the No. 1 Doc Crandall. The wildcat topped the Nozu sand, middle Miocene, at 5040 ft, and flowed at the daily rate of 489 bbl.

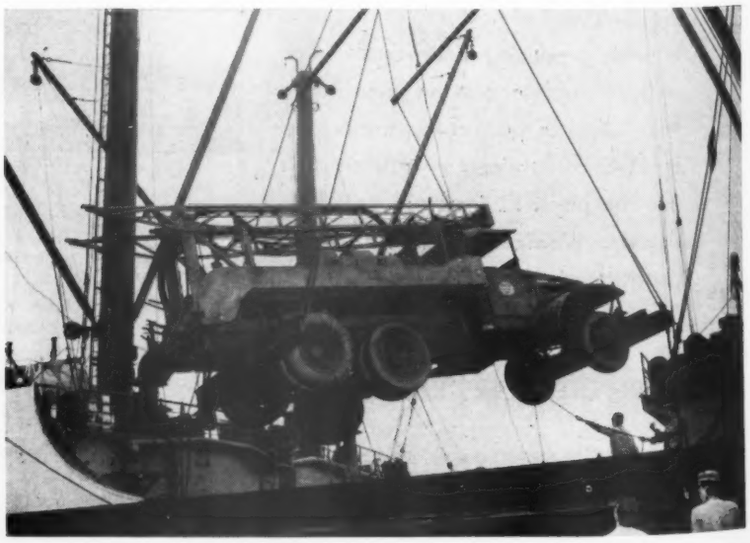
## COLORADO

★ A flow of 1200 bbl of oil daily through a ½-in. choke on test of the "D" sand discovery, 1 Spinner, Weld County, has been reported by S. D. Johnson and Cortlandt Dietler, Denver. The wildcat is in the South Greasewood area. These operators now have a second well, No. 2 Spinner, at total depth of 7200 ft; casing is being run.

## FLORIDA

★ Gulf Oil Corporation, et al, were moving in pumping equipment for their No. 1 State of Florida-340, 34 miles west of Miami in Dade County. It is the third discovery well for the state. The well swabbed 9 bbl of 22.2-gravity oil an hour from the Sunniland Lime at 11,350-352 ft, in open hole.

**J. R. Monkhouse, left, and Sam D. Rogers, president of Rogers Geophysical Company, were on hand to check on more than 1700 items sent to Africa.**



**A shot hole rig truck is lifted off the dock to be lowered into the hold of the SS Borneo for shipment to a Rogers Geophysical Company crew in the Italian Somaliland to be used in East Africa survey.**

# IS THERE A DIFFERENCE IN CORE ANALYSES?

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At no stage during the productive life of an oil field does the quality of reservoir information become more pronounced than during financial negotiations for the purchase or production of reserves. With such data, *from a recognized source,* the points of economic reality are more quickly resolved. Without it, negotiations often disintegrate.

The development of reliable core analysis data goes far beyond the mere compilation of mechanically-procured information. Frequently, when the inconstant behavior of a particular reservoir contradicts the results of routine laboratory procedure, interpretation must be integrated with the logic of past experience and research in many other areas.

Core Lab data from 28 area facilities are accepted by financial organizations as accurate, comprehensive information based on *18 years' experience, 25,000 individual core analyses, and 700 different reservoir fluid analyses.*

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NEW ORLEANS, SHREVEPORT, HATTIESBURG, JACKSON, LAFAYETTE, DENVER,
BAKERSFIELD, WORLAND, STERLING, BILLINGS, CASPER, EL DORADO, LUBBOCK,
FARMINGTON, LOVINGTON; CALGARY, EDMONTON, REGINA, CANADA; VENEZUELA, S. A.

CORE LAB
PETROLEUM RESERVOIR ENGINEERING



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## Exploration

### WYOMING

★ Vickers Exploration, Ltd., has announced completion of its government Canada Southern No. 1 well in Niobrara County, for a natural flow rate of 20 to 25 bbl of oil per hour through a 2-in. choke. Production came from the Newcastle sand perforated at 7645 to 7657 ft.

### CANADA

★ A gas discovery in British Columbia west of the Buick Creek field and north of the Ft. St. John field was reported by Canada Southern Oils, Ltd. Tests of the Pacific Union Buick Creek No. 1 well indicate an open flow potential of some 15,000 cu ft. Flow came from two intervals between 4695-4740 ft.

★ Discovery of Mississippian production in a Stanolind Oil and Gas Company wildcat well some 65 miles southwest of Edmonton, Alberta, has been reported. The Mississippian was topped at 6602 ft in the wildcat, the Stanolind No. 1 Cynthia Crown A. In a drill-stem test, oil was at the surface in 15 min and the well was shut in after 30 min. Flowing pressure was 500 lb, Stanolind reported.

The well is six or eight miles north of the Pembina field. The regular Cardium sands being produced in Pembina were not present.

### TEXAS

★ Tennessee Production Company has opened production in the Lower Strawn zone at its No. 3 Porter, in the Garvey-Strawn field, one and one-half miles east of Farmer in Young County, north Texas. Previous pay was in the upper and middle sections of the Strawn. With pipe perforated at 3816-26 ft, the well flowed 274 bbl of oil a day through a 16/64-in. choke, with GOR of 300-1. Total depth was 3856 ft.

★ A 13,000-ft exploratory test will be made by Magnolia Petroleum Company, six miles offshore from Jefferson County. The company will use a platform rather than a barge for the work. Indications are that work on the marine equipment is to begin immediately. Drilling site is 11 miles southwest of the mouth of the Sabine River.

★ The Texas Company announced location of its first Texas tidelands wildcat, which will be drilled offshore approximately four miles from the south edge of High Island field, Galveston County.

Special equipment will be used, including a modified platform for the derrick, drawworks, and pipe rack and a floating tender for power equipment and mud pumps.

The test well is projected to a depth of 9500 ft. It is planned to spud in in May or early June.

### ILLINOIS

★ National Associated Petroleum Company has completed its fourth discovery in recent weeks on the coal anticline in Franklin County. National's No. 1 Old Ben at South Christopher produced 160 bbl on completion from the Aux Vases sand at a depth of 2640 ft.

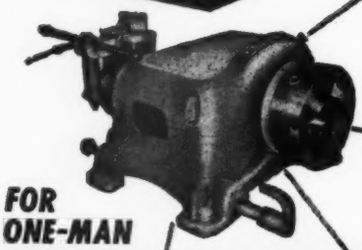
Its No. 1 Old Ben at North Christopher was completed in January pumping 100 bbl a day from the Aux Vases sand at a depth of 2610 ft.

Also completed in January was National's No. 1 Valier Coal at North Valier. This well produced 100 bbl per day from the Aux Vases at a depth of 2640 ft.

### LOUISIANA

★ Stanolind Oil and Gas Company and King and Heyne of Houston announced joint completion of a discovery well in a new producing area at Raceland dome, La Fourche Parish, South Louisiana. On a six-hour test, the companies' No. 1 C. E. Gheens flowed 38 bbl of distillate and 1,411,000 cu ft of gas through a ⅛-in. choke. Tubing pressure was 3700 psi. Drilled to a total depth of 14,700 ft, the well was completed between 12,900-910 ft in the top 10 ft of a 110-ft sand. It is approximately one mile north of present production from a shallower zone.


Introducing the NEW
BEAVER Lightweight Aluminum
Model-D Power Drive
$202.50



Beaver No. 102 — P D Wide Roll Pipe Cutter made especially for power drives.

Beaver Model 77-Drive Threader is ideal for use with new Model-D.

FOR ONE-MAN OPERATION AND PORTABILITY

- Works on bench, truck or pipe legs!
- Flat top serves as tool tray!
- Side openings give motor ventilation and act as hand grips for moving!
- Approximately 100 lbs. net weight!
- All gears run in oil!
- Convenient operator switch!
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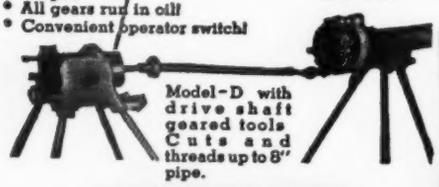
- Safety-locked switch lever!
- Bronze spindle bearings!
- Attractive baked enamel finish!
- Parts interchangeable with Model-C.



Model-D with drive shaft geared tools. Cuts and threads up to 8" pipe.

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**LOOK AT SHIPPING FACILITIES.** With the new Seamless mill located in Chicago, on the Calumet River, shipments can be made to oil fields everywhere by water down the Mississippi as well as by rail.

**CENTRALIZE YOUR BUYING.** You can get both your Seamless and Electric Weld Casing and Tubing from one source. This cuts down paper work, makes it easier to keep track of what supplies you have and what you need.

**ADD IT ALL UP.** If you want quality and convenience, get the whole string from Republic. A call to your nearest Republic Sales office will bring you all the facts.

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REPUBLIC STEEL

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# RUNNING TOUR with MEN in the INDUSTRY

**Clarence M. Netherland** has joined Gruy and Durst, Fort Worth petroleum and geological engineering firm. Netherland has a degree from the University of Tulsa, Oklahoma. His experience includes three and a half years as an engineer for Sohio Petroleum. He has spent the last one and a half years with Southern Production Company in Fort Worth.

**Haden J. Upchurch,** land department manager for Texas Eastern Production Corporation has been elected vice president. In addition to new administrative duties Upchurch will continue to manage the activities of the land department.

H. J. Upchurch

Upchurch joined Texas Eastern Production in 1952. Prior to that he was district landman for the Cabot Carbon Company in Midland, Texas, and before that he was employed by the Humble Oil. He studied law at the University of Texas.

**Charles R. Dodson** has joined The National City Bank of New York as petroleum engineer. Dodson until recently has been a partner in the petroleum consulting firm of Stanley, Stolz and Dodson. In his 17 years experience in the petroleum engineering field he has served as head petroleum engineer for the northern district, Standard Oil of California and head of the petroleum engineering department for the University of Southern California. He is a graduate of University of Maryland and MIT.

**Robert B. Bossler,** vice president and chief engineer for Brundred Oil Corporation, has been named director of production research for the Pennsylvania Grade Crude Oil Association.

Bossler is a nationally known authority on production of petroleum by secondary recovery. With the Brundred Corporation since 1935, he has had charge of its engineering in development and operation of properties by water-flooding and air and gas drive in Pennsylvania, Kentucky and Kansas.

**Herbert Parker** has been named chief geologist for Gulf Coast division of Sun Oil Company. He will assume duties formerly held by K. V. Schroeder, who was both chief geologist and manager of the land department. Schroeder still is land department head and assistant manager of the division.

**R. W. (Bill) Taylor** has been named editor of the Journal of Petroleum Technology. Announcement was made by the petroleum branch of American Institute of Mining and Metallurgical Engineers.

**Joseph G. Lambert,** geological engineer, has joined the staff of Earlougher Engineering, "Petroleum Consultants and Core Analyses," Tulsa, Oklahoma. Upon Lambert's graduation from Princeton University in 1948 he was employed by Stanolind Oil and Gas Company in Rangely, Colorado, and in Casper and Cody, Wyoming, specializing in reservoir engineering.

**R. E. (Dick) Duty,** consulting petroleum geologist, Mt. Vernon, Illinois, has moved his offices to Denver, Colorado. He was previously with W. C. McBride, Inc., for over 12 years, as district geologist of Oklahoma, Kansas, and North Texas.

**Bruce L. Wilson** has resigned from The Texas Company to form the consulting firm, Wilson Engineering, in Mt. Vernon, Illinois. The firm will specialize in reservoir analyses, design, and operation of secondary recovery projects, and property evaluation.

**George H. Truran, Jr.,** of Bakersfield, California, has been promoted to superintendent of the operating department of Tide Water Associated Oil's San Joaquin Valley area district. He will replace **Thomas E. Weaver** of Oildale, California, who has been transferred to the company's Los Angeles area with headquarters at Los Nietos, California, replacing Frank C. Foster, who has retired.

Truran joined Tide Water in 1946 as a production engineer in the company's San Joaquin Valley district. He was graduated from Purdue University.

**Charles F. Elder** has been named staff petroleum engineer, The Texas Company. Elder has been assistant to the division manager of the company's Oklahoma division at Tulsa since 1953. His new headquarters will be in New York City. He was graduated from the University of Oklahoma in 1940 and after graduation joined Texaco.

**Roy L. Lay** has been named assistant to the vice president, Texaco. Lay has been manager of the geophysical division of the producing department at Houston, Texas, since 1950. His new headquarters will be in New York City.

F. A. Nice, Jr.

**Frank A. Nice, Jr.,** has joined the staff of Hurt Oil Company, Ltd. in Houston as manager of drilling and production operations. Formerly he was associated with Texas Gulf Producing Company as petroleum engineer in both domestic and foreign operations. Nice was graduated from Texas A & M.

**M. N. Broughton** has been named staff geologist to the vice president of the producing department of The Texas Company.

Broughton was graduated from the University of Texas. In 1949, he was promoted to senior geologist, New Orleans, then in 1952, he was named division geologist, South Texas division.

**J. A. Quigley** will replace Broughton as division geologist, South Texas division of the producing department.

Quigley received his degrees from Princeton University. He was employed by Texaco as a junior geologist in the West Texas division at Midland in 1939. In 1952, Quigley was transferred to the general manager's staff as the senior geologist.

**W. W. Rowe,** rotary helper, Grand Isle district, Louisiana Division, Humble Oil and Refining Company, was promoted to district electrical foreman on LST of Rig No. 36 at Grand Isle. **H. B. Taylor,** crane operator, Grand Isle district, Louisiana division, was promoted to district electrical foreman on LST of Rig No. 46 at Grand Isle.

O. L. Furse, Humble district superintendent of the Athens district, East Texas division, was promoted to assistant division superintendent, East Texas division, replacing **C. M. Vardaman,** deceased. **B. E. Crowder,** assistant district superintendent of the London district, East Texas division, was named district superintendent at Athens. **Ralph T. Russell,** assistant district chief clerk, Pickton district, East Texas division, transferred to the Stratton district in Southwest Texas division in the same capacity.

**Walter C. Cornelison,** Humble assistant district chief clerk, Maurbro district, Gulf Coast division, was transferred to the Pickton district to replace Russell. **M. M. Martin,** assistant district chief clerk, Stratton district, transferred to the Maurbro district replacing Cornelison.

**Dandridge W. Marston,** civil engineer, Gulf Coast division office, was made district civil engineer at the Kelsey district, Southwest Texas division.

Howard E. Slater, purchasing agent for the foreign production division of Gulf Oil Corporation has announced his retirement from active service with the company. Slater joined the Mexican Gulf Oil Company in Tampico, Mexico, in 1922. In 1927 he was transferred to the Venezuela Gulf Oil Company and during his term of service there initiated a program of warehouse standardization.

In 1930 he was transferred to New York as purchasing agent for Gulf's foreign production operations. He remained in this position until his retirement.

**Tom Jennings,** petroleum engineer in Sumatra for Stardard-Vacuum, recently spent some time in the offices of Magnolia Petroleum Company, Dallas, Texas, making studies of latest petroleum engineering methods.

**J. I. Laudermilk,** production department coordinator, Socony-Vacuum Oil Company, Inc., New York, recently made a trip to the Southwest for the purpose of visiting the petroleum industry and leading educational institutions.

# What's NEW

In Perforating, Logging, and Fishing Tool Services

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NEW SERVICES • NEW TOOLS
NEW WAYS OF DOING THINGS

*Latest News About New Tools, Techniques and Services*

### 2 hours and 35 minutes

**PROBLEM:** New Well. Operator wanted well bullet perforated fastest way.

**SOLUTION:** McCullough 4¼" M-3 Bullet Gun Perforator shot 334 ½" holes in 7" 23-lb. J-55 cemented casing between 4013' and 3940'. Eight runs were made to perforate 73 feet of zone. (26' at two holes per foot and 47' at six holes per foot.)

**RESULT:** Job was completed during a snow storm in two hours and 35 minutes. Good well. Production figures not given.

## NEW Perforators SOLVE Toughest Problems!

### 0 B/D to 120 B/D

**PROBLEM:** Well had been drilled, tested, plugged and abandoned. Another company, believing production was possible, bought old hole and set 5½", 17-lb. casing.

**SOLUTION:** McCullough Neutron Log located two thin potential zones. Both thin intervals were accurately perforated (48 shots total) in one run in the hole using McCullough Standard Casing Glass Jet Perforator and Steel Strip Carrier (10,032' to 10,038' and 10,042' to 10,048').

**RESULT:** Well came in flowing at 120 barrels per day.

# McCULLOUGH

## Perforating Service

## M-3 Bullet Gun and Glass Jet *Perforators*

### 75 B/D to 250 B/D

**PROBLEM:** Well had been perforated through 7" casing by another company and was producing 75 B/D. 7" casing went bad and a string of 5" was run inside and cemented. The operator wanted to regain production.

**SOLUTION:** McCullough Super Casing Glass Jet Perforator and Steel Strip Carrier fired 176 shots at 9155' through both strings of casing and cement.

**RESULT:** Production was increased from 75 barrels per day to 250 barrels per day. Time on the job—two and one-half hours.

## "World's Hardest Shooting"

### *Results after others failed*

**PROBLEM:** Hard, shaley-sand had to be sandfraced to get production after perforating. Well had been perforated by another service company on three different occasions (four jet holes per foot). Formation would not break down under pump pressure up to 3000 lbs.

**SOLUTION:** McCullough Tool Company was called on the job. Twenty ½" bullets were fired, three holes per foot, by our M-3 Perforator.

**RESULT:** Formation broke down under 600 lbs. pump pressure. Time on the job—one hour. Resulting production—50 barrels per day.

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To obtain more information on products advertised see page E-61



XUM

## Running Tour

**George M. Lees,** chief geologist of the Anglo-Iranian Oil Company, Ltd., London, England, received the Sidney Powers Memorial Medal of the American Association of Petroleum Geologists. The gold medal and scroll were presented to Dr. Lees at St. Louis, Missouri, at the 39th annual meeting of the AAPG, meeting jointly with the Society of Exploration Geophysicists and the Society of Economic Paleontologists and Mineralogists.

**John L. Rich,** professor of geology at the University of Cincinnati, and **George S. Hume,** chief, Geological Survey of Canada, Toronto, Ontario, have been elected to honorary membership in AAPG.

**Charles C. Bates,** deputy director, division of Oceanography, U. S. Navy Hydrographic Office, has been chosen 1954 recipient of President's Award of AAPG.

The President's Award is given to the author under 35 years of age whose article appearing in the monthly *Bulletin* of the AAPG during the preceding year is judged by the Medal Award Committee to be the "most significant original contribution to petroleum geology." His winning paper was entitled "Rational Theory of Delta Formation."

**Dr. Heinz Andree,** head of the geological and petroleum laboratories of Deutsche Vacuum Oel AG., Celle, Germany, is spending several months in the United States studying modern petroleum laboratory methods and equipment. He was in Texas the middle of March and was going on to California before returning to Germany.

**John A. Murphy,** chief reservoir engineer for Continental Oil Company, has been promoted to assistant to vice president. Murphy joined Continental in 1948 as a reservoir engineer, and became chief reservoir engineer in 1950.

Succeeding Murphy is **Wallace W. Wilson,** who has been assistant chief reservoir engineer. Wilson has been with Continental since 1950.

**John R. Spencer,** since 1952 supervising reservoir engineer, has been promoted to assistant chief reservoir engineer to succeed Wilson. A graduate of California Institute of Technology, Spencer, and has been with Conoco since 1951.

Promoted to supervising reservoir engineer, succeeding Spencer, was **William L. Boyd, Sr.,** who has been a Conoco reservoir engineer since 1950. He holds degrees from the University of Oklahoma.

**Jack K. Baumel,** formerly director of production and chief engineer oil and gas division, Railroad Commission of Texas, has announced opening of his office as consultant in petroleum and natural gas engineering.

**Harry W. Bass,** Dallas, president of Texas Mid-Continent Oil and Gas Association, was honored with a dinner and reception at the Texas Hotel recently. He recently ended a state-wide series of meetings in Fort Worth, with an address before oil and gas producers from this area of Texas. He had met with producers in eight other Texas areas in a tour sponsored by his association.

**E. D. Loughney** has been elected a vice president of the Canadian Gulf Oil Company. This is a subsidiary of the Gulf

E. D. Loughney

Oil Corporation and is one of its principal operating companies in the Dominion. Loughney, who has been general manager of the Canadian Gulf Oil Company with headquarters at Calgary since 1951, will continue to be responsible for the company's expanding oil exploration and production operations in Canada.

**A. S. Rhea** has been named superintendent of the operating department for Sun Oil Company's southwest division, succeeding **John A. Ritter,** retired. Rhea joined Sun as a chemist in 1927, becoming chief petroleum engineer for the southwest division in 1947. A graduate of the University of Texas, he was formerly chief petroleum engineer and assistant superintendent, operating department.

Ritter, a graduate of the University of Colorado, joined Sun in 1923. He has been with Sun 31 years.

**F. G. (Gus) Prutzman** will succeed Rhea as division petroleum engineer. He has been assistant chief petroleum engineer. He first joined Sun in 1937, after graduation from Texas A & M.


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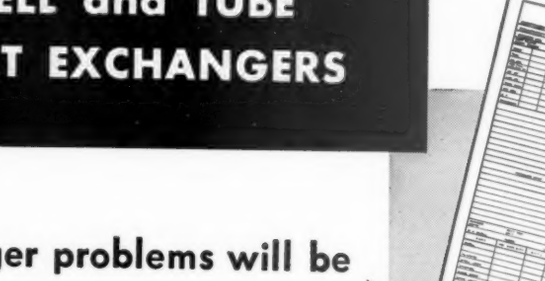

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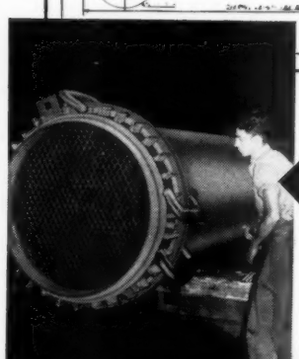

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### "Recession Upward"

While the dying screams of professional gloom-dispensers shatter business ears with wails about depression, excessive unemployment, staggering businesses, and all the makin's of an "economic crisis", chemical firms, including especially petrochemical manufacturers, are going about the job collecting data that show almost without exception increased production, bigger sales, and better earnings. Sales and earnings are up 5 to 15 per cent over 1952. Construction will 'taper off' probably in 1954 but will still be high. The rush to catch up with delayed wartime-period normal building expansion is largely over, but natural expansion will continue "from now on."

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### Texas Ammonia Plant?

United Chemical Company has large plans for an $18,000,000 plant in Texas to make ammonia and urea from natural gas and air-nitrogen. Foster Wheeler has the building contract, but actual start depends on a bond-vote among local people at Timpson, to raise $250,000 for a water supply. A 166-acre site will be given the company, if bonds carry. The New York-money backed company plans 250 daily tons of ammonia, 90 tons urea.

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### No Union for Lab Men

Association of Professional Engineers, Chemists and Scientists wanted to unionize professional men at Texaco laboratory at Port Arthur, Texas, but the company said no exclusive bargaining deal. APECS screamed to NLRB, who ordered an election among the lab men. Engineers, chemists, and scientists said *NO UNION* to the score of 51 to 41. Hard to regiment individualistic scientific minds.

★ ★ ★

### Cleans Charge Stock

Process for replacing sulfur, nitrogen, and oxygen with hydrogen in hydrocarbon stocks, removal of metals, and saturation of olefinic components is presented to the industry for licensing and operation by Union Oil Company of California and Universal Oil Products Company under the name of the Unifining Process. License covers rights and protection of patents held by both companies. For example, process is used to 'clean up' charge stocks for the Platforming process, from which hydrogen is obtained for the Unifiner unit, and also for upgrading cat cracker charge stock shale oil distillates, jet fuels, diesel fuels, kerosines, etc.

The first unit of this process to be installed has just begun operation at United Refining Company, Warren, Pennsylvania, to treat 750 bbl per day to yield sulfur-free products such as kerosine, mineral oils, etc. Blaw-Knox's Chemical Plants Division, Tulsa, designed and built this United unit.

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### Engines Compete

A great amount of research must be carried out on the gas turbine to enable it to compete with the piston engine, says Max Roensch, of Chevrolet Research. A 235-hp gas turbine will use 8 to 10 gal of fuel per hour while idling, and a piston engine at the same time will use only 0.7 to 1 gal per hour. Experimental engines in trucks and cars show that a car so powered will do 150-odd miles per hour; a truck on steady near-maximum load will show good economy. Big opponent of the gas turbine in locomotive and truck operation is the efficient diesel engine, which must be equalled to give the gas turbine a chance, Roensch said.

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### Biggest Reformer

Gulf Oil Corporation, Port Arthur, Texas, is to build the biggest Platformer in the world. Contract has been let to Fluor, Los Angeles, for design, engineering, and construction of this unit, to process 29,000 bbl of charge per day. UOP is to do process design.

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### "The French Are Coming!"

Early in April a group of French engineering consultants will reach this country and go in a huddle with a group from the Association of Consulting Chemists and Chemical Engineers, at a luncheon at Park Sheraton Hotel, New York City, April 7. Meet is sponsored by Foreign Operations Administration, Washington, with N. E. Philpot presiding. Purpose is to develop firmer contacts between American and foreign consultants, to exchange information and to discuss the role and function of the professional consultant here and abroad.

### Hydrocarbon Analysis

Accurate, standardized analytical procedures for determination of composition of hydrocarbon samples are hard to come by. Natural Gasoline Association of America is sponsoring a cooperative project whereby 76 laboratories will collaborate in analyzing a standard sample, composition of which is known only to the blender who makes it up. Phillips Petroleum made up the sample, and project is in charge of A. J. Miller, chairman of NGAA's Fractional Analysis Committee and a member of Phillips' staff. Sample is a deethanized natural gasoline.

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### Synthetic Ammonia in Utah

Synthetic ammonia plant will be built at Salt Lake City to process 3,600,000 cu ft of natural gas daily to produce 120 tons daily of ammonia largely for agricultural consumption in the mountain country. Also to be made are 30 tons per day of "dry ice," solid carbon dioxide. The plant will use the Claude ammonia synthesis process, and 108 tons of oxygen per day will be separated from air by refrigeration and fractionation.

Engineering design is under way. Construction will begin in the second quarter of 1954 and the plant is expected to be on stream in the third quarter of 1955. A 100-acre site is purchased about two miles outside the city limits of Salt Lake City. Design and construction are being done by Tears Engineers, and Henry C. Beck.

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### Cat Reforming Expansions

More catalytic reforming units are going in, announced recently, to swell the soaring capacity in this very important field. Texas Company is building a Platformer at its New Jersey Eagle Point Works, of 12,000 bbl daily capacity design, with Procon, Inc., as builder. A 2000-bbl per day alkylation unit is also building, to supply blending material for aviation fuels. Additionally steam generation capacity of 275,000 lb per hour will be added, also more than 300,000 of storage capacity. Expansion is to be completed by January 1, 1955.

A new Platformer is being built at Petco Corporation's Chicago, refinery to augment the motor fuel production of the Houdry cat cracker unit there. Cost will be $1,000,000 and Procon Inc. will build it.

### Synthetic Glycerin

Street echoes indicate that Atlas Powder Company may be planning to make synthetic glycerin from sugars, such as sorbitol, and rumors begin with the Certificate of Necessity granted them, for about $6,000,000, recently. Patent in question is Bottoms, USP 2,335,731. Germans are said to have run a process during World War II to make glycerin from sugar, getting also substantial amounts of glycols and polyols (polyhydric alcohols, having more than one hydroxyl group, -OH, per molecule). Plant said to be scheduled for the Midwest Farm Belt area. So far Atlas doesn't monkey with hydrocarbons, much.

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### New Motor Fuel Out

A new motor fuel is placed on the market by Phillips Petroleum, that contains both di-isopropyl and HF alkylate, ultra-high octane rating materials employed mainly in aviation fuels for reciprocating engines. Military forces do not now require all these components that are being manufactured, so that the excess is blended to make a fuel of higher octane rating, for general sale. Both products are synthetic, and their production was stimulated greatly by World War II. Increased use of jet fuels at the expense of conventional aviation fuels is one factor in this situation.

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### Methyl Mercaptan Plant

Manufacture of methyl and other mercaptans at the Chemicals Division of Pan American Refining Corporation, will be undertaken as soon as plant facilities are built at that company's Texas City, Texas, refinery site. Plant capacity is, tentatively, about 5,000,000 lb per year. The process employs hydrogen sulfide and methanol (wood alcohol), and has been developed via extensive pilot plant research at Texas City. Ethyl and propyl mercaptan may be made in the plant, also, and capacity production is expected about January, 1955.

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### Mechanical Brains

Working on calculations dealing with synthesis of products, and research and experimental operations, modern calculating machines may do in 30 hours the work that will require one man 20 years to complete by hand calculators, The American Institute of Chemical Engineers were told recently by a group of chemical engineers meeting early in March at Washington. Such computations can minimize a great amount of time and work in pilot plant and scale model testing work. On processes being developed, it may even tell whether or not products can be made, without going through the long-drawn-out experimental operations employed universally up to now, "they say."

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### More Sinclair Sulfur

A new sulfur recovery unit, operating on refinery gases, has just been contracted for by Sinclair Refining Company for its Houston, Texas, refinery. Ralph M. Parsons Company, will design and build it, the sixteenth sulfur plant by that engineering company. Unit will make 30 tons of sulfur daily from hydrogen sulfide waste gases for the plant's refinery operations.

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### Study Carthage Hydrocol

A thoroughgoing study of the economics and general position of the synthetic fuels unit now shut down at Brownsville is under way by Stanolind Oil and Gas. Job is assisted by Hydrocarbon Research Inc., of New York, who had a hand in the original work leading up to the plant now studied. Lummus Company is also brought in as consulting contractor. Group will survey plant facilities, modifications, and additional facilities that may be needed, with view to possibly reopening operation of the plant.

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### Gasoline Plant On Stream

A Platforming unit, solvent refining, and a benzene recovery unit have just gone on stream at the refinery of Eastern States Petroleum Company, Houston, built by Brown and Root, Inc. An alkylation unit using a Kellogg sulfuric acid cascade reactor process is part of the system. The products will be supplied to the armed services, R. N. Blaize, Eastern States executive vice president has announced.

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### Ammonia for Canada

Dow Chemical of Canada, Ltd., has awarded contract to Fluor Corporation, to build an expansion to its ammonia production at Sarnia (Ontario). H. G. Acres, of Niagara Falls, Ontario, will engineer the plant expansion, which will be completed late in 1954. Cost is approximately $3,000,000.

### Champlin to "Sell Out"

Negotiations are under way, rumor says, for the sale of Champlin Refining, Enid, Oklahoma, to Chicago Corporation; astronomical figures such $55,000,000 are mentioned in print as the purported price. Only people not talking are the ones who know the figure. Champlin is one of the oldest independent refineries. Chicago Corporation began as an investment concern, became owner-operator of natural gas and gasoline properties, and this would give it its first refining — oil-producing-pipe-line system.

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### More Fertilizer

Rumor says Celanese Corporation is casting sheep's-eyes at sites for a new fertilizer venture in the South Mississippi River basis. Sewing-Circle chatter is to spend $10,000,000, and make 150,000-200,000 tons/year.

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### Brazilian Refinery Set

A refinery to process 45,000 bbl per day of crude for Brazilian consumption is building by Arthur G. McKee Company, of Cleveland, Ohio. Plans were made in New York, and designs and details worked out in Germany and France. Equipment was bought in France and United States, and McKee then began construction at the Cubatao, Sao Paulo. Construction is expected to be completed in August, 1954.

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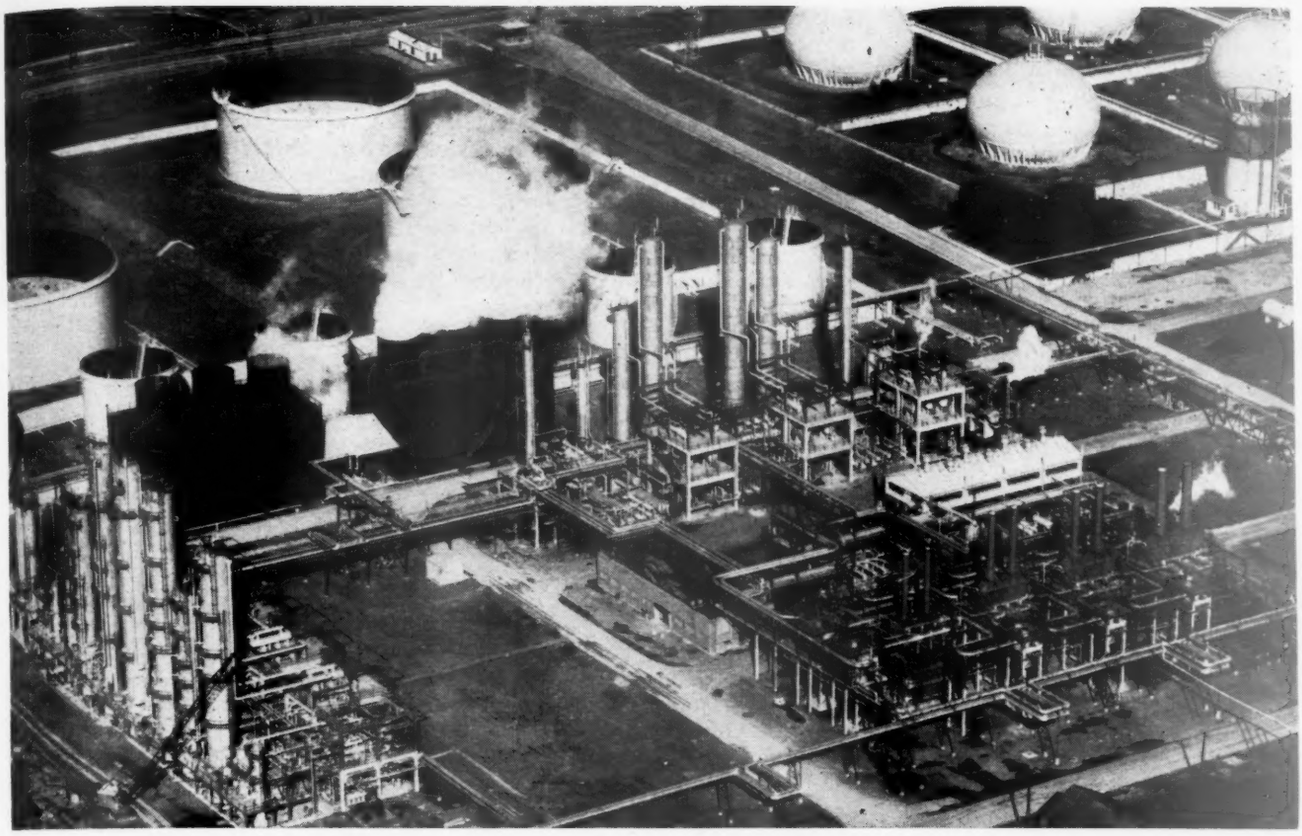
### $1000 for Teachers

Blaming the current shortage of chemists on a "dearth of adequately trained science teachers," Standard Oil Foundation, Inc., is granting $1000 to Indiana University to foster advanced training of science teachers in public schools. This sum will finance Fellowships for five high school teachers working toward advanced degrees, (M.A., M. S.) in chemistry teaching, chosen from Indiana teachers. University will waive tuition and fees, so fellows chosen will use money to defray personal expenses. This is a sad commentary on the notion that held immediately following World War II — there were too many chemists, engineers, they said then. Students turned to economics, etc., now we have too few chemists to meet demands.

And Russia is turning out twice as many scientists; question there is — how much true science do they know, how much Communist-science? Two expressions are not synonymous.



**Sun Oil Company's new Houdriformer unit at Marcus Hook, Pennsylvania, where more than 50,000,000 gal of aromatic hydrocarbons will be made annually.**

# PETROCHEMICALS IN HIGH GEAR

## 1954 Indications: More competition ahead, development of more skillful salesmanship, overproduction in some important products

E. B. BRIEN*

UNTIL very recently, increases in the production of petrochemicals have been spectacular and practically universal, much like the rise of the stock market in 1928. The general trend is still upward and will continue upward for a few more years, particularly with some of the newer industrial products. There are definite indications, however, of increasing competition in some of the products now made in large volume by many companies. These are mainly products that can be made freely without patent restrictions of any kind (ethylene glycol, ethylene oxide, perhaps ethyl alcohol, and others).

In the coming years, the more successful companies will be largely those who hold patents. The patentless companies will feel the production-squeeze. The indicated solutions for all companies in the future of petrochemicals are increased research for new products and new uses, and a return to skillful salesmanship.

### Capital Investments

The trend in 1953 appeared to be continued expansion of capital investments in the petrochemical industry, and the continued entrance of petroleum companies, suppliers of the basic raw materials, into petrochemical production. Chemical companies already experienced in this production began expanding their activities to the stages of final products.

**EXCLUSIVE**

At the end of the year, 58 oil companies were producing petrochemicals; 79 chemical companies were already in the field, and 6 companies formed by a petroleum and a chemical company were in operation. Investment of petroleum companies in the petrochemical industry, however, is still relatively small compared to their total investments.

Total petrochemical investments at the end of 1953 are estimated to be somewhat more than $3 billion. In the next six years, they are expected to increase by another $5 billion. Such forecasts may appear optimistic and "off the cuff" until one stops to analyze forecasts of some years ago: Every responsible forecast studied has proved to be more conservative than what

*Eastern Editor.

eventually occurred in actual investment, production, and sales.

Trends observable in the past year were principally along four lines. Established companies in the field have reorganized departments and raised petrochemical activities to more autonomous and independent status. Such, for example, was Goodyear's establishment of its chemical division into a separate division of the company; Shell Chemical's forming a separate ammonia division; Diamond Alkali's forming two major divisions, a chlorinated and a plastics division; the complete reorganization of Monsanto; Semet-Solvay's organizing a petrochemical division; American Cyanamid's creation of four new divisions, etc.

Reasoning behind similar moves is that the type of manufacturing and selling peculiar to the petrochemical industry is foreign to the historic thinking of oil men. Oil companies most successful in petrochemicals are those that formed a subsidiary — like Shell: They acknowledged the intricacies of the new field by acquiring experienced manufacturing staffs and providing adequate organization to make and sell the new kind of products.

The second trend has been the entrance of more capital into the industry by means of large, established, but non-petrochemical, firms sometimes buying into smaller, established petrochemical companies. W. R. Grace & Company, a shipping firm, has invaded the chemical field so wholeheartedly it should soon rank among the 10 top chemical companies in the United States. It now owns almost two-thirds of Davison Chemical's stock; last year it formed Grace Chemical Company which is now headed by a former Shell Chemical man. Borden recently acquired American Polymer Company of Peabody, Massachusetts; Surpass Petroleum, Ltd., Toronto, purchased Alox Corporation, New York, producers of petrochemicals; Reichhold Chemical, Inc. took over Watson-Park Company, of Ballardvale, Massachusetts. Mathieson also entered the petrochemical field, as well as National Distillers — whisky makers — with National Petro Chemical Corporation.

A third trend was a steady increase in funds — certainly upward of $300,000,000 in 1953 — apportioned for technical research and marketing studies. Technical research was primarily concerned with improving processes to cut production costs — other than with new products and uses. Marketing research concerned itself with finding new markets for the increased production provided by technical research.

A final trend in late 1953 and for 1954 is an increase in competition. Salesman thinking appears to be the dominant executive factor indicated for the coming months.

Investments in 1954 for capital outlays for all industry give appearances of equalling 1953's $34 billion in new construction. The president of United States Steel Corporation believes this year's total may even surpass last year's by $2 billion. In these estimates, the petroleum, chemical and petrochemical industries will invest their own proportionate shares. In production, transportation, distribution, and servicing of plant and equipment for 1953, about $58 billion — or $4 billion more than 1952 — were spent according to the Council for Technological Advancements.

This $58 billion is believed to be apportioned roughly as follows: 65 per cent in equipment, 22 per cent in construction, and 13 per cent in maintenance and repair.

The South, now producing about one-fourth of all chemicals, has one-third of the nation's processing industries. The Gulf Coast, by the end of 1953 had about 80 per cent of its 1951 and 1952 DPA certificates of necessity in place, or about $590,000,000 in new construction. The remaining $145,000,000 should be completed this year.

Petrochemical investments in all other sections of the country were believed to be around $3 billion, an increase of about $500,000,000 over 1952.

The petroleum industry spent approximately $4.2 billion in 1953, according to the Chase National Bank, including all phases of production, transportation, refining, and marketing. If there is any drop in 1954, it should appear in transportation; the other three branches should hold or increase their activities.

In spite of the fact that most economists believe that 1954 will show a 5 per cent decline in national product, the first three months of the year show the opposite trend. New plants and equipment early this year actually showed an increase over 1953: $6.5 billion in 1954 compared to $6.1 billion in 1953, according to the SEC and the Department of Defense estimates. A similar trend is reflected in the petroleum industry which spent about $690 million for the same period last year, reports the Department of Commerce. A small part of this amount was spent on coal products.

Economics today is closely related to politics, a factor which should not be overlooked. There may accordingly be some common thread among the prophets of doom and among the business leaders. It does seem to be a fact that the vast majority of the VIP's who are currently proclaiming a depression is on the way are politicians out of power. Could they be crying "wolf" as a political trick to return to power?

It is also a fact that businessmen on the whole disagree wholeheartedly with the political prophets. Of businessmen polled recently in New York, over ⅓ thought their volume would equal 1953's; over ¼ thought their business volume would increase somewhat, while 5 per cent predicted gains of over 15 per cent; about 24 per cent expected a moderate decline, and only 3.5 per cent expected a 15 per cent decrease in their sales.

Last year was a good year for Americans. Goods and services produced increased by 5 per cent over the previous year: $368 billion. Personal income went up 6 per cent to $285 billion. Business had a good year too, the best in the last four. Net income after taxes so far reported by some 2350 corporations shows a hefty 10 per cent increase over 1952.

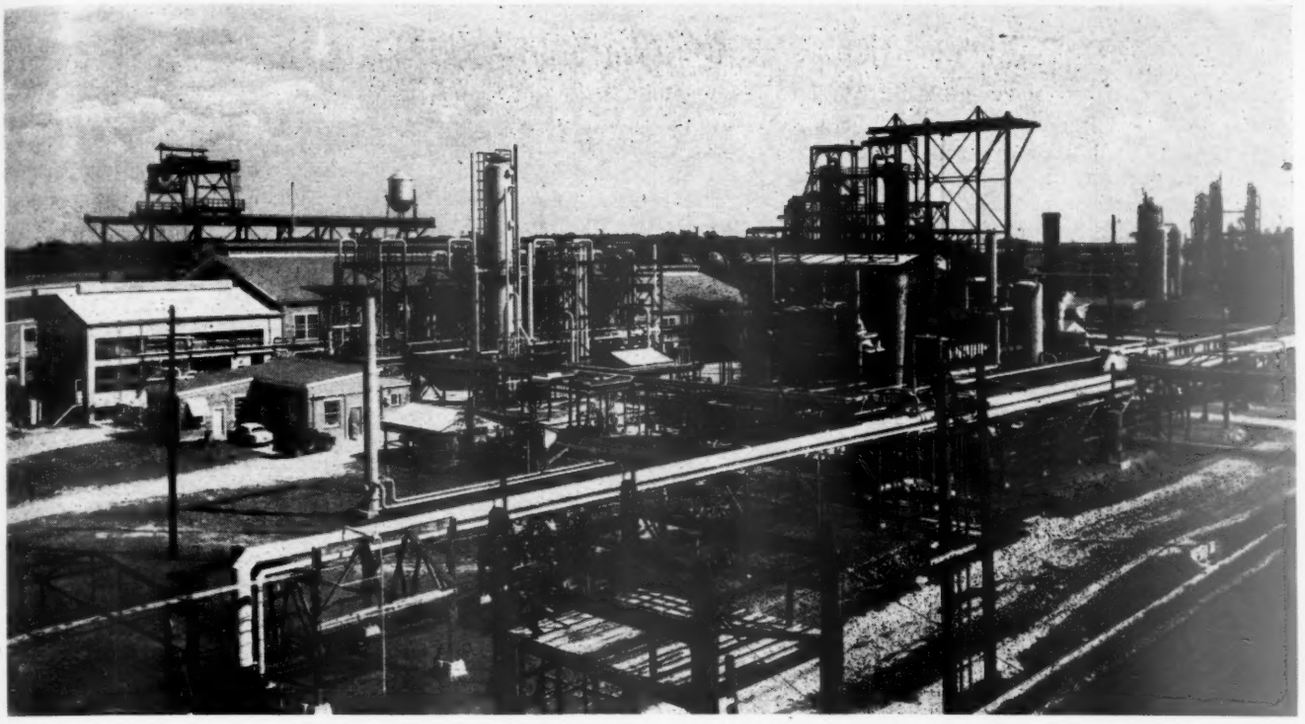
### Aromatics

The use of aromatic hydrocarbons (benzene, toluene, xylenes), basic to the petrochemical industry, depends on the demand for intermediates and end-products made from them. Recently, several important changes have occurred in their production, as well as their demand for other products.

Production-wise, the petroleum industry began making benzene on a sizable scale about 4 years ago. In 1950, it produced from petroleum or natural gas a total of 10,100,000 gal (72,900,000 lb). The next year the industry tripled its production to 32,700,000 gal; but it raised capacity only slightly in 1952 to 35,500,000 gal. In 1953, the industry increased its productive capacity by 40 per cent, up to 50,000,000 gal. From 1950 to 1954, the petroleum producers, therefore, increased their share of capacity from just below 2 to about 18 per cent.

Two major units to produce aromatics were put on stream last year. Shell Oil Company came on stream in the Spring with a new Platforming unit at Houston with a 19,000,000 gal benzene and 33,000,000 gal toluene capacity. In December, Sun Oil put its own unit on stream at Marcus Hook with a capacity of 19,000,000 gal benzene, 19,000,000 gal toulene, and 15,000,000 xylenes. These two plants alone can produce 2,000,000 gal of benzene more than the entire industry in 1952.

Two other sizable, though smaller, units also were begun in 1953: Oronite Chemical Company's 12,000 bbl Platformer at El Segundo and Great Southern Chemical Corporation's 10,000 bbl plant at Corpus Christi. Two Houdriformers also went into operation:



**Methanol (foreground) and ammonia units (background) of Commercial Solvents Corporation, Sterlington, Louisiana.**

Crown Central Petroleum Corporation's 5000 bbl plant at Pasadena, Texas and Petrocarbon Chemicals, Inc.'s, 1000 bbl unit at Irving, Texas.

Production-wise the situation would appear to be well in hand. This may be even more so if one adds the fact that over 40 catalytic reforming plants (mainly Houdriformers and Platformers) are now operating to produce high-grade gasoline; with the installation of appropriate separating units, these could be switched to aromatics production.

The bulk of benzene is produced by coke-oven operators whose production, of course, is geared to the steel industry; they produce 179 million out of a total of 272,000,000 gal in 1953, 155,000,000 of a total of 251,000,000 in 1952, and 173,000,000 out of a total of 266,000,000 in 1951.

The third source of benzene, tar distillers, dropped significantly from 61,000,000 gal in 1952 to about 42,500,000 in 1953, probably due in part to the greater use of natural gas as fuel.

The benzene production goal set by the NPA for national preparedness has a high of 375,000,000 gal for 1955, a goal well on the way to realization.

The 100 or so extra million gallons in capacity now required to meet the NPA 1955 goal must come almost completely from the petroleum industry, as demand for steel — or coke — cannot be expected to increase more than a small fraction. Such a rapid expansion in the next two years could certainly spell overproduction — a gamble industry must take in the light of national safety. Paradoxically, the fear of overproduction may be somewhat dimmed by the prospects of continued increases in demand for intermediates and end-products. Should an international crisis develop, the NPA goal could be reached quickly by building separation sections to the reforming units now producing high octane gasoline.

**Benzene production and sales. (million gallons)**

| Year | Production | Sales |
|---|---|---|
| 1942-46 average | 139.6 | ... |
| 1947 | 167.6 | 151 |
| 1948 | 173.8 | 156 |
| 1949 | 133.0 | 128 |
| 1950 | 186.0 | 172 |
| 1951 | 265.7 | 234 |
| 1952 | 251.6 | 217 |
| 1953 | 270.5 | 255 (est) |
| 1954 | 325.0 (est) | 310 (est) |
| 1955 | 375.0 (est) | 360 (est) |

**1953 Benzene production. (million gallons)**

| Month | Tar Distillers | Petroleum operators | Coke Oven Operators |
|---|---|---|---|
| January | 3.6 | 5.1 | 16.1 |
| February | 1.3 | 3.8 | 14.3 |
| March | 4.5 | 4.2 | 15.9 |
| April | 4.5 | 4.1 | 15.4 |
| May | 3.5 | 4.0 | 15.4 |
| June | 4.5 | 5.0 | 14.5 |
| July | 4.2 | 5.0 | 14.3 |
| August | 3.9 | 3.6 | 14.1 |
| September | 3.0 | 3.6 | 13.8 |
| October | 2.6 | 3.0 | 15.3 |
| November | 3.0 | 4.1 | 14.8 |
| December | 3.6 | 3.8 | 15.1 |
| | 42.2 | 49.3 | 179.0 |

**Benzene production by petroleum operators. (million gallons)**

| Year | Gallons |
|---|---|
| 1950 | 10.1 |
| 1951 | 32.5 |
| 1952 | 35.5 |
| 1953 | 50.0 |
| 1954 | 75.0 (est) |
| 1955 | 100.0 (est) |

### Consumption

Originally, the American Coke and Chemical Institute had placed benzene demand at 250,000,000 gal for 1953 and the same amount for 1954. Sales in 1951 were close to that goal: 234,000,000 gal; in 1952, sales dropped to 217,000,000 gal; although no sales figures are available for 1953, it would appear that the Institute's 250,000,000 gal forecast has been reached — if not actually surpassed.

About one-third of all benzene goes into styrene, much of which is made into synthetic rubber, and into polystyrene, a molding powder. On that basis, about 86,000,000 gal of United States production were consumed in these two products in 1953.

Phenol, also a major consumer of benzene, accounted for around 51,000,000 gal in 1953, or almost one-fifth of production. The remaining production went into various products, no one of which took a substantial share. Synthetic detergents are estimated to have absorbed the next largest portion of benzene, 16,000,000 gal, or around 6 per cent; chlorobenzene took another 6 per cent. Aniline and DDT each consumed about 14,000,000 gal with BHC and maleic anhydride each absorbing around 5,000,000 gal.

### Toluene

Up until late in 1953, more than 70 per cent of all toluene was reserved

for the production of trinitrotoluene and aviation gasoline, a situation that made for a tight market. Toluene production has shown a substantial growth in the past 4 years, jumping by 58 per cent from 1950 to 1953.

The production of toluene from petroleum sources has varied very widely in the past. For example, at the peak of production during the war, it is believed that toluene soared to 400,000,000 gal in one year, most of it coming from petroleum sources. Over ¾ went to the armed forces, almost ⅕ to aviation gasoline, and only 6 per cent to other uses. After the war, these petroleum producers for the most part switched their production to automotive fuel; civilian demands were met by the other two producers, coke-oven operators and tar distillers.

### Future Demand

The DPA put a 1955 toluene production goal of 180,000,000 gal, three times the annual capacity of about 58,000,000 gal prior to the Korean conflict. This goal means new capacity for 51 million gal over the 1953 production of 133,000,000. Without considering new uses, this goal should be reached. The aromatics plants mentioned above will contribute a substantial amount. Shell Oil's Houston plant that came in early in the year has a capacity for 33,000,000 gal toluene; Sun Oil's Marcus Hook unit came on stream too late to produce much in 1953, but it has a design capacity of 19,000,000 gal per year.

Oronite's and Great Southern's two Platformers, with charge capacity for 12,000 and 10,000 bbl per day, also came on stream in 1953. These units boosted total production from 105,000,000 in 1952 to 133,000,000 in 1953. In 1954, at least two other plants are scheduled to come on stream though both are relatively small.

### Consumption

Other than for military uses, toluene does not have many large-volume civilian uses; it is used mainly for protective coatings, dyestuffs and miscellaneous chemicals. For most of 1953, it was in short supply — a situation helped by the fact that one large supplier was out of production a good part of the year. Cessation of actual fighting in Korea has not eased supply, as had been expected. The high production of automobiles — and the consequent demand for lacquer — absorbed all production the government had not commandeered beforehand. Government demand for toluene in aviation gasoline is not expected to ease off for another 3-4 years in spite of the change to jet aircraft.

Shortly before the Korean war, toluene joined benzene as a chemical building block in a small way for making detergents and vinyl toluene (to replace styrene) for synthetic rubber, paints and varnishes.

American Cyanamid's new 1953 process to produce vinyl toluene (methylstyrene) out of toluene or dimethyl styrenes out of a mixture of xylenes may add an extra incentive to the recovery of this aromatic from petroleum fractions.

**Toluene 1953 production.**

| Coal Oven operators | Month | Others |
|---|---|---|
| 3.07 m. gal | Jan. | 4.68 m |
| 2.77 | Feb. | 5.33 |
| 3.10 | Mar. | 8.03 |
| 2.98 | Apr. | 8.92 |
| 3.04 | May | 9.78 |
| 3.06 | Jun. | 9.78 |
| 3.12 | Jul. | 6.87 |
| 3.06 | Aug. | 9.54 |
| 2.95 | Sep. | 7.36 |
| 3.17 | Oct. | 10.38 |
| 3.06 | Nov. | 7.40 |
| 3.19 | Dec. | 8.78 |
| 36.57 | | 96.85 |

Toluene Production

| Year | Petroleum Operators Production |
|---|---|
| 1950 | 45,458,000 gal |
| 1951 | 55,708,000 |
| 1952 | 64,040,000 |

Xylene Production

| Year | Petroleum operators Production |
|---|---|
| 1950 | 62,356,000 gal |
| 1951 | 64,413,000 |
| 1952 | 61,554,000 |

**Total production**

Toluene

| Year | |
|---|---|
| 1949 | 81,751,000 gal |
| 1950 | 83,871,000 |
| 1951 | 101,415,000 |
| 1952 | 105,297,000 |
| 1953 | 133,410,000 |
| 1954 | 185,000,000 (DPA goal) |

Xylenes

| Year | |
|---|---|
| 1949 | 57,557,000 gal |
| 1950 | 71,892,000 |
| 1951 | 75,660,000 |
| 1952 | 71,727,000 |
| 1953 | 101,390,000 |

**Xylenes — Total production.**

| | Year 1953 Month |
|---|---|
| 7.25 m | Jan. |
| 5.04 | Feb. |
| 9.24 | Mar. |
| 9.27 | Apr. |
| 7.35 | May |
| 8.83 | Jun. |
| 5.12 | Jul. |
| 7.39 | Aug. |
| 11.26 | Sep. |
| 10.52 | Oct. |
| 9.92 | Nov. |
| 10.20 | Dec. |
| 101.39 | |

### Xylenes

In 1953, xylenes began to get the attention the other two aromatics had been receiving as true building blocks for chemical and petrochemical products. Productive capacity for the various xylene isomers (ortho, para, meta) increased by over 40 per cent over 1952. 1952 production was 71.7 million gal, while 1953 production jumped to 101,000,000 gal.

One of the major plants to come on stream in 1953 was Humble Oil's para-xylene, Baytown, Texas plant with a capacity of about 3,500,000 gal. Standard Oil (California) made its initial move by opening its El Segundo para-xylene plant in September. In 1952, Standard had produced about 276,000 gal; but at its El Segundo and Richmond, California, plants it will be able to produce 4,825,000 gal by early this year. Phillips Chemical Company opened a smaller 690,000 gal plant at Big Spring, Texas, two months ago.

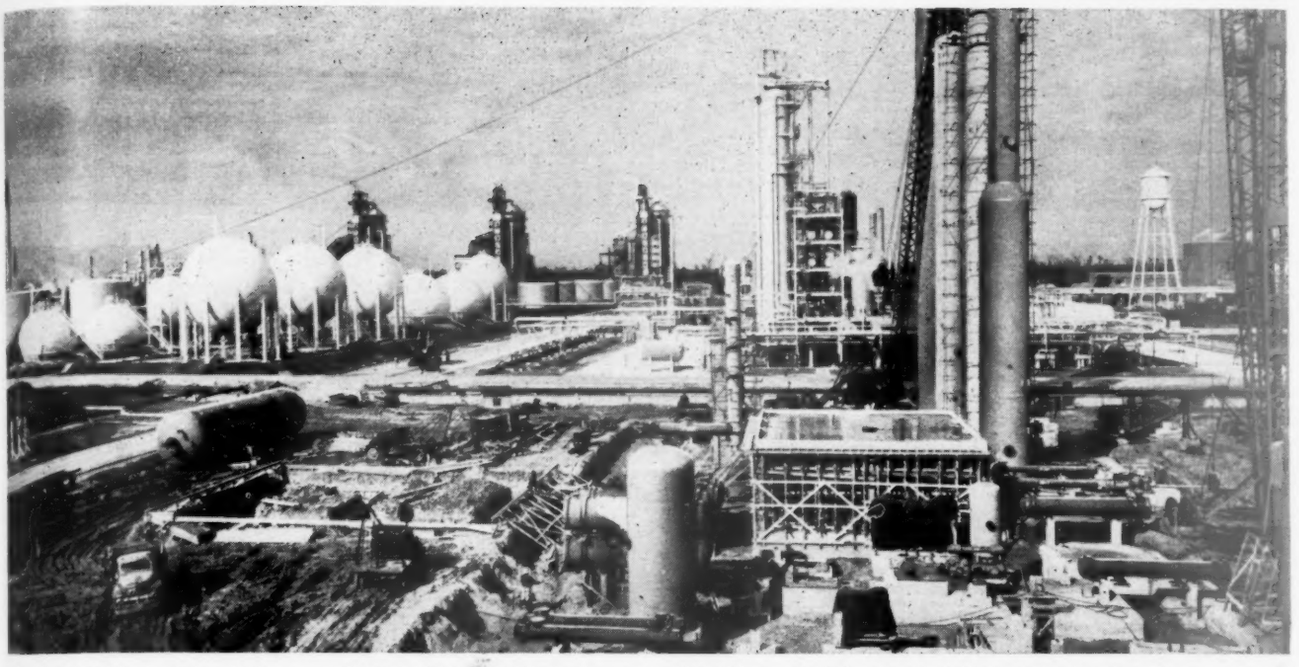
Shell's plant at Houston does not produce xylene, but Sun at Marcus Hook has a 15,000,000 gal per year capacity. Other plants contributing to the 40 per cent increase were Oronite at El Segundo and Great Southern at Corpus Christi. Scheduled to come into production this year are Crown Central Petroleum Corporation, a 5000 bbl Houdriformer at Pasadena, Texas, and Petrocarbon Chemicals, Inc. (a new subsidiary of Stender Oil Corp.) a small 1000 bbl Houdriformer at Irving, Texas. Early in 1955, Sinclair Chemicals, Inc. plans a 1,380,000 gal per year unit at Marcus Hook.

Industry sources indicate that another 9-11,000,000 gal of xylene capacity will be added by 1955. This is to meet the demand created by the new uses for polyester fibers, films and plasticizers. The synthetic fiber, Terylene — Dacron, in the United States — is a rising synthetic. Para-xylene is used to make terephthalic acid, a raw material for Dacron. Also using terephthalic acid is Du Pont's polyester film, Mylar; the latter will be produced in a $10 million plant now abuilding at Circleville, Ohio.

Hercules will be the first company to use a new oxidation process to manufacture the intermediate, terephthalic acid, in a new $4 million plant plant now being built at Burlington, New Jersey.

Terephthalic acid makes para-xylene an important raw material. Industry sources forecast a 114,000,000 lb demand by 1960 to manufacture ethylene-glycol-terephthalate fibers. Humble Oil's new Baytown fluidized plant of 25,000,000 lb capacity should initially provide a large portion of the para isomers required in the production of these fibers.

The intricate, *intercompany relationships* illustrated here for para-xylene, its intermediate and final product, is becoming common for many petrochemicals. In this case, Sinclair Chemical at its Marcus Hook refinery will make the basic raw material, para-xylene, from which Hercules will produce about 12,000,000 lb of the intermediate, dimethyl phthalate; Canadian Industries, Ltd. will use the intermediate to make Terylene for which it is now building a plant in Ontario. In this particular case, it is worthy of note that Hercules has no basic position in



**The half-finished state of the new 17,250-bbl Fluid Hydroformer unit building at Cities Service's Lake Charles, Louisiana, refinery, to make either high octane number fuels or petrochemical intermediates.**

the raw material; in like manner, its production of dimethyl phthalate hinges upon the production of Terylene fiber by a third firm. As the petrochemical industry develops, similar relationships among various companies are becoming more extensive.

Ortho-xylene, converted to phthalic anhydride, finds a substantial market in alkyd resins and plasticizers for vinyl and nitrocellulose resins. Oronite Chemical, subsidiary of Standard Oil (California) and the first to use the oxidation process from ortho-xylene to phthalic anhydride some 9 years ago, has been producing it commercially since 1947. Major production —about 90 per cent—however, comes through catalytic oxidation of naphthalene with air. Allied's Barrett Division in mid-1953 completed a 2,500,000 lb phthalic anhydride plant from naphthalene at Calumet, Illinois and will complete a second plant early this year in Philadelphia. The ending of American Cyanamid's strike loosened the market somewhat in late 1953. Isophthalic should compete with phthalic anhydride in various uses.

Isophthalic acid is due for a major production increase in the near future, based on the fact that Oronite's recent $4 per pound reduction for developmental quantities of isophthalic acid should stimulate use-research and on the fact that Standard Oil (California) is planning a $10,000,000 plant to produce 50,000,000 lb per year.

### Ethylene

In spite of ethylene's being virtually nonstorable and economically prohibitive to transport — only one 200 mile pipe line exists — it is in the first or second position of the large-volume organic chemical intermediates. Its principal production comes as a by-product from chemical cracking of ethane and propane.

Kuhn and Hutcheson predicted a conservative 4 billion pounds of ethylene by 1960, although Egloff in the Paley Report years back had predicted a high of 4-5 billion pounds by 1950.

The ethylene news in 1953 came chiefly from two companies: Gulf Oil Corporation opened the largest ethylene plant in the world at Port Arthur with a capacity of 2.5 billion cubic feet per year; early this year it announced a still larger plant to be built at the same site. The combined capacity of both plants should produce close to 20 per cent of national output: 5.5 billion cubic feet per year.

The second company, the fully integrated National Petro-Chemicals Corporation's plant at Tuscola, Illinois, put its unit on stream late in 1953. Among the products to be made from the 400,000,000 cu ft of natural gas per day, will be a reported 200 million pounds of ethylene per year.

Spencer Chemical Company plans shortly to build an ethylene plant at Orange, Texas. With Spencer, there will then be a minimum of thirteen major producers of ethylene, four of which are oil companies. Of these only Gulf Oil has noncaptive ethylene for sale to chemical manufacturers on a yearly basis; it also has the only ethylene pipe line in the country beginning at Port Arthur.

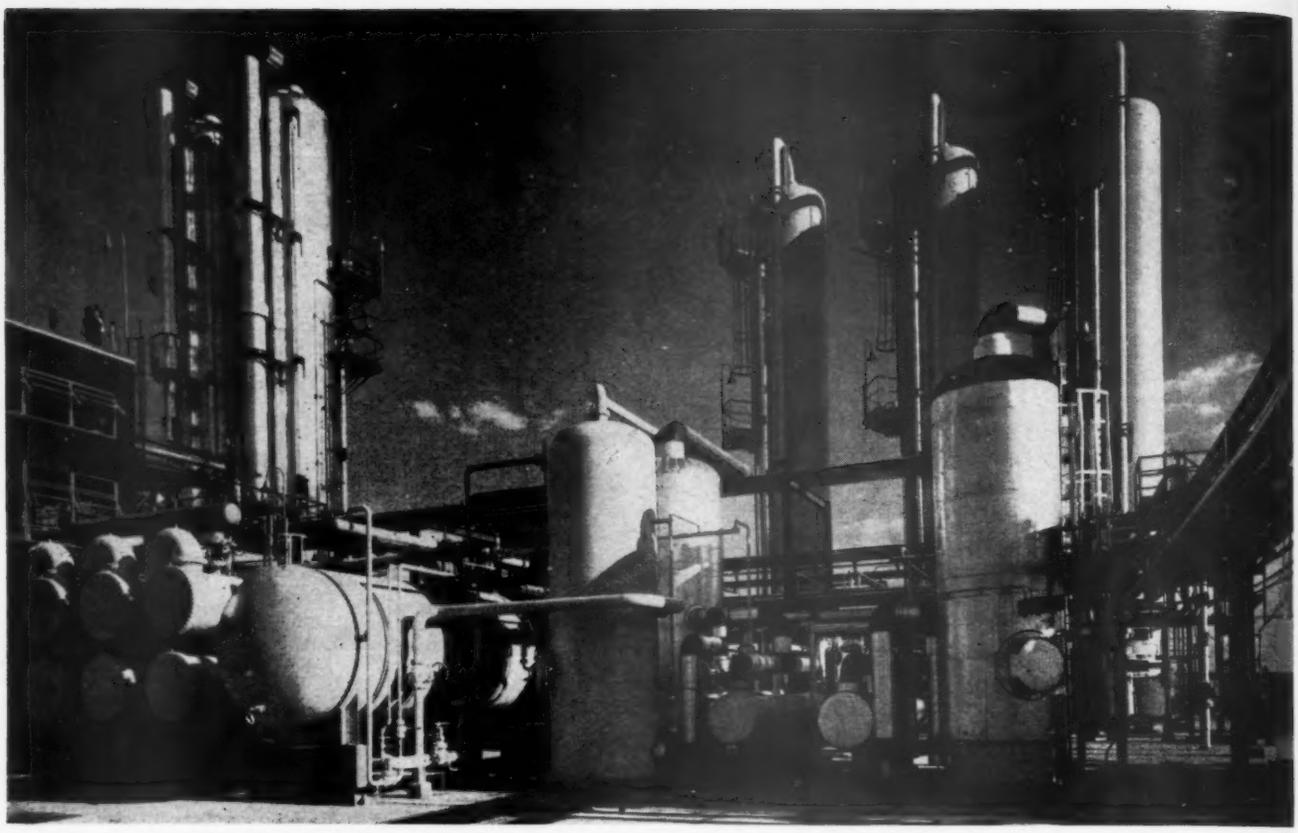
Many products of prime importance are made directly from ethylene and scores of others are made from the first products by processes involving two or more reactions. One company lists at least 50 industrial products that evidently begin from ethylene as raw material. The most important chemicals made from it are ethylene oxide, ethylene glycol, acrylonitrile, alkylolamines, polyglycols, glycol ethers, and nonionic detergents.

Production of ethylene oxide is estimated at close to 750,000,000 lb in 1953; and by 1955 it is expected to surpass the 1 billion pound mark.

The DPA 1955 goal is placed at 900,000,000 lb. Allied Chemical and Dye (Nitrogen Division) built a $5,000,000 ethylene oxide — via oxidation — plant at Orange, Texas, to come fully on stream early this year, and Hancock Oil is planning a new unit on the West Coast.

A change in the production process is making its appearance for ethylene oxide. The chlorohydrin process, first followed by Carbide, has been partly replaced by the competitive process of direct oxidation of ethylene by air. Two engineering firms, Vulcan and Lummus are now offering the direct oxidation process. Vulcan uses the fluid catalyst method developed by Atlantic to remove the highly exothermic heat of reaction, while Lummus follows Shell Development's fixed bed method. The direct oxidation method is probably cheaper than the chlorohydrin process.

Production of ethylene glycol has grown from 192,000,000 lb in 1946 to 761,000,000 lb in 1952. About three-quarters goes into antifreeze. Sep-



**Hydrocarbon extraction section at National Petrochemicals Corporation's Tuscola, Illinois plant.**

arate secondary uses are all below 6 per cent of total production, a trend that apparently will hold in the next few years.

### Acrylonitrile

Acrylonitrile may be made both from ethylene oxide and acetylene, with the latter gaining in importance in 1953. American Cyanamid's Fortier plant in Louisiana, expected to open shortly, plans to use natural gas to make acetylene, and react it with hydrogen cyanide to make acrylonitrile. The three fibers (Orlon, Acrilan, Dynel) using acrylonitrile as raw material require an average of three-fourths pound of acetylene for 1 lb of fiber. The Kuhn forecast estimated in 1950 that about 170,000,000 lb of acrylonitrile would be needed by 1962. Along with the expected increase in plastics and other minor uses, the same estimate places a demand of around 380,000,000 lb in 1962; there appears little evidence to modify this figure in 1954. In terms of ethylene oxide required for acrylonitrile, it was estimated that 192 million of the 380,000,000 lb would come from that intermediate. The new production of acrylonitrile, as noted above, however, will be made by reacting acetylene with hydrocyanic acid, HCN.

### Polyethylene

The spirit of the entire petrochemical industry is demonstrated by the great gamble the industry has taken in polyethylene. Nine companies are putting one-fourth billion dollars in polyethylene plants; by 1957 when these plants are on stream, production will have jumped fivefold up to almost 600,000,000 lb. Union Carbide is currently the largest producer and its ultimate capacity will range up to 255,000,000 lb. Its 60,000,000 lb Texas City plant came on stream in December, 1953; a second plant at Seadrift, Texas is scheduled for mid-1954 completion and a third one at Torrance, California, will also be constructed.

Du Pont should complete a twofold expansion, up to 100,000,00 lb in March at the Sabine River, and Monsanto will produce another 100,000,000. Spencer will produce 45,000,000 lb at Orange, Texas. National Petro-Chemicals, and Dow plan a production of about 25,000,000 lb each; Texas-Eastman has plans for a 20,000,000 lb plant at Longview, Texas. Allied Chemical, (Semet-Solvay) at Buffalo put its 20,000,000 lb plant on stream in January. Koppers Company expects to be in production in 1955, probably at Port Arthur; it will supply the raw material to the manufacturers of coatings, bottles, and pipe. Canadian Industries, Ltd., at Edmonton, Alberta, plans to spend $1,000,000 in 1954 to increase the capacity of its plant by one-third.

Polyethylene is made from ethylene which is polymerized at 35,000 psig at moderate temperatures, 300-500 F, technically a difficult process. Overproduction is almost assured; extensive research for new uses and intelligent salesmanship, however, should be able to sell all production, as the plastic has unique characteristics.

All polyethylene forecasts predict a billion pound market by the early 1960's. Its uses are many and large. Films (packaging of produce and soft goods) and coated papers accounted for 40 per cent of the market in 1953. Electrical insulation took 35 per cent of production last year. Because of its high dielectric constant AT&T is coating its transatlantic telephone cable with it, The squeeze bottle market has a high potential: 250,000,000 squeeze bottles using polyethylene will be made this year, and over 3000 cosmetic and pharmaceutical products are bottled in polyethylene. The glass industry is much aware of the squeeze bottle. Last year, Owens-Illinois bought a half interest in Plax Corporation, the largest squeeze maker, "to join the enemy."

Plastic pipe is a rising polyethylene consumer; in 1953, three major steel-pipe manufacturers entered the plastic pipe field.

A sound imagination and a realistic grasp of the industrial and commercial spheres should be able to push the polyethylene market even beyond the billion pound limit now visualized.

A definitive study of polyethylene

may be found in Fortune Magazine, February, 1954: "The Polyethylene Gamble."

### Acetylene

About three-fourths acetylene produced in 1953 served as a chemical raw material for vinyl and acrylic plastics, fibers, nitrile rubber and acrylonitrile soil conditioners. Several hydrocarbon processes of producing acetylene exist outside the traditional method via calcium carbide: They are distinguished mainly by the source of energy.

Thermal cracking uses heat from a cracking furnace (Wulff thermal); partial oxidation receives heat from the hydrocarbon's burning with air or oxygen (Sachsse); and the experimental electric discharge process has the hydrocarbons passing through an electric arc (Schoch process).

There are now four hydrocarbons-to-acetylene plants in the United States. Monsanto's at Texas City came on stream in January, 1953; its acetylene goes into acrylonitrile and vinyl chloride.

Carbide and Carbon has the largest plant in the United States in Texas City.

American Cyanamid is shortly to complete an acetylene plant at Fortier, Louisiana, that uses the Badische process, a variation of the Sachsse process. Wulff Process Company has a small demonstration plant using liquid propane as raw material near Los Angeles. Rohm and Haas may build its own hydrocarbon plant in the near future. Hayden-Monsanto, at Texas City uses its own acetylene by-product gas to make methanol for which it is building a 25,000 gal per year plant.

Industry sources predict that by 1955, demand for acetylene should near 1 billion pounds and five years later 2 billion pounds. This growth trend is postulated on the increasing demand for vinyl chloride and acetate, neoprene, and trichloroethylene, acrylonitrile, and high pressure acetylene compounding, all of which are destined for great increases in production.

To meet this demand, the calcium carbide sources that produced 750,000 tons in 1950 should reach 1,500,000 tons next year and 3,000,000 tons in 1960. Natural gas accounts for only about 10 per cent of total production at present but by 1975 is expected to jump 75 per cent. Reasoning here is that the calcium carbide process is fully developed, while the hydrocarbon approaches are new and still to be developed. The new Wulff Process is now being offered by three engineering and construction firms, Fluor, Girdler, and Lummus. This process, using natural gas or light hydrocarbons, reportedly reduces the production costs of acetylene by over one-third if made in sufficiently large quantities.

Ethylene and acetylene may be used alternately for many products. For example, almost half of the vinyl chloride (for polymerization of synthetic resins; it is used in greater volume than any other material in thermo-plastics) produced comes from acetylene, half from ethylene. Both raw materials are also used to make acrylonitrile, acetic acid, and chlorinated hydrocarbons.

### Plastics

In 1953, Hermann Staudinger of Germany received the Nobel Prize for chemistry for his work in high polymers. The plastics industry received in him a belated acknowledgement that has been verified in actual growth last year. For example, latest information showed that in 1953, the production of phenolic resins was increasing at the rate of 49 per cent over 1952; polystyrene was going up at 43 per cent, cellulosic plastics were expanding at 41 per cent and the vinyls at 20 per cent.

The growth of plastics in 1953 was persistent and impressive. Three billion pounds of raw materials were produced in 1953, 30 per cent higher than 1952. Indications are that 1954 will show a notably smaller, but still good, increase, up to about 3.15 billion pounds. Valuewise, all plastics products neared $1.5 billion in 1953. Among other reasons for such rapid growth, one is the increasing production of raw materials from petroleum and natural gas because of new or enlarged productive facilities. In terms of molders, sales increased 34 per cent over the first 10 months of 1952.

One pronounced trend in 1953 in the plastics industry was the consolidations, mergers, or purchases within and without the industry. Metal firms for example, bought into plastics: Youngstown Sheet and Tube bought Perrault Fibercase Corporation; Cooper Alloy Foundry Company (valves, pumps) bought part of Vanton Pump Company; Minnesota Mining and Manufacturing acquired Gustin-Bacon Manufacturing Company's patents on glass fiber-reinforced plastic pipe. Allied Chemical and Dye bought Plaskon division of Libbey-Owens-Ford Glass Company. Celanese Corporation bought control of Marco Chemical Company of Camden, New Jersey, thus making its entry in polyester resin.

The use of plastic pipes in the industry is growing rapidly: 1953 sales were more than three times greater than five years ago, or up to about $17,000,000. They are now used to handle, natural gas, oil, chemicals and water. They are used in Alberta oil fields and in chemical plants. One company reported a $2000 maintenance saving on a 400-ft plastic pipe line in its chemical plant.

New uses of plastics were frequent occurrences last year. Naugatuck Chemical Division (U.S. Rubber Company) developed a plastic-metal laminate. New wood, glass, and plastic combinations appeared. Plastic bodies of automobiles became a reality. Tank trucks to transport chemicals and milk trucks were unveiled during the year. Plastics in trailer trucks are reported to save 1000 lb, a notable weight reduction.

In reinforced plastics the use of polyester resins in the past 9 years increased from 3,500,000 lb in 1945 to an estimated 26,000,000 lb in 1953; in 1954, production of these resins is expected to jump another 9,000,000 lb.

Resin and glass fiber producers, molders and fabricators continued their normal 30 per cent growth last year and promise to go on at the same rate in 1954.

**Synthetic resin production.**
**(U. S. tariff commission)**

| Year | Pounds | Tons |
|---|---|---|
| 1922 | 5,944,133 | 2,972 |
| 1927 | 13,452,230 | 6,726 |
| 1928 | 20,411,465 | 10,205 |
| 1929 | 33,036,490 | 16,518 |
| 1930 | 30,867,752 | 15,433 |
| 1931 | 34,179,000 | 17,089 |
| 1932 | 29,039,000 | 14,519 |
| 1933 | 45,200,202 | 22,600 |
| 1934 | 56,059,489 | 28,029 |
| 1935 | 95,133,384 | 47,566 |
| 1936 | 132,912,821 | 66,456 |
| 1937 | 163,030,410 | 81,515 |
| 1938 | 130,358,652 | 65,179 |
| 1939 | 213,027,548 | 106,513 |
| 1940 | 276,814,363 | 138,407 |
| 1941 | 428,325,692 | 214,162 |
| 1942 | 426,731,106 | 213,365 |
| 1943 | 653,332,000 | 326,666 |
| 1944 | 784,137,600 | 392,068 |
| 1945 | 818,020,000 | 409,010 |
| 1946 | 994,277,000 | 497,138 |
| 1947 | 1,251,699,000 | 625,849 |
| 1948 | 1,480,876,000 | 740,438 |
| 1949 | 1,491,111,000 | 745,555 |
| 1950 | 2,150,518,000 | 1,075,259 |
| 1951 | 2,431,408,000 | 1,215,704 |
| 1952 | 2,333,924,000 | 1,166,962 |
| 1953* | 3,000,000,000 | 1,500,000 |
| 1954* | 3,150,000,000 | 1,575,000 |

*Estimated

Other trends were apparent: General Electric and Monsanto set up new technical service and development programs, including a research center for customers ($1,250,000) and Bakelite initiated a merchandising program for plastics. New producers have entered the field and expansion programs have been announced by Diamond Alkali, Dow, Goodrich, Monsanto, and U.S. Rubber among others.

New products kept entering the market. Mylar, Du Pont's polyester film, will be produced on a large scale in a new $10,000,000 plant now building. The film is used in metallic textile yarn, electrical insulation, acoustical tile, liners for drums and other containers, etc. Shell Chemical Corporation tripled its production of epoxy

resin in a new plant at Houston early this year.

All in all, industry spokesmen are in agreement that 1954 will be better than 1953 for the plastics industry.

### Synthetic Rubber

Late in 1953, the 25 government synthetic rubber plants now under RFC control were put up for sale: 13 GR-S plants, 8 butadiene plants, 2 butyl rubber plants, 1 styrene and 1 dodecyl mercaptan plant. For sale or lease are the two butadiene-from-alcohol plants at Louisville, Kentucky and Kobuta, Pennsylvania, both of which have been shut down since mid-1953. Ultimate transfer of plants to private industry cannot take place earlier that May 29, 1955, however.

Total capacity of these facilities amount to 860,000 long tons of GR-S, 539,000 short tons of butadiene, 90,000 butyl rubber, and 57,000 short tons of styrene. The butadiene-from-alcohol plants have a capacity of 215,000 short tons.

Denationalization of the synthetic rubber industry promises to be a highly complex economic and political maneuver. Buyers, for example, must agree to keep their purchased capacity available for 10 years. Synthetic prices have been fixed low and natural rubber prices are now higher than synthetic. Under these conditions, the use of natural rubber jumped from 39.6 per cent in January, 1953, to 45.5 per cent of total consumption at end of the year.

Still, private industry appears eager to buy. Principally interested are the large rubber companies, seemingly the natural buyers, petroleum companies that produce the raw materials and smaller tire and fabricating companies who might not want the plants to pass entirely to the big firms.

Use of natural rubber in 1953 rose 22 per cent to 555,000 long tons, while synthetic rubber consumption fell slightly to 781,000 long tons, for a record-breaking total of 1,341,000 long tons. Last year saw the first decrease in the use of synthetic rubber since 1941 when only some 6000 tons were consumed. Use of neoprene, however, jumped over 15 per cent in 1953. This year's consumption is expected to fall off a few percentage points.

Preliminary figures on synthetic consumption for 1953 are:

| | |
|---|---|
| GR-S (government-made) | 623,896 long tons |
| Neoprene (duPont) | 64,023 |
| Butyl (government-made) | 77,755 |
| N-type (3-4 companies) | 15,939 |
| | 781,613 |

The government's plants operated in 1953 at their highest profit in their 12-year history — though had they paid federal taxes, this total would have fallen to a modest 6 per cent of sales.

### Detergents

Synthetic detergents are made from several petrochemical raw materials, especially alkylated benzenes that are sulfonated, and the nonionic detergents made from ethylene oxide.

Production in 1953 showed a modest growth over the preceding year, but detergents established a first: For the first time, production and sales of the synthetics surpassed those of soaps. Production of detergents stood at 1.86 billion pounds compared to 1.64 billion pounds for soaps. Dollarwise, sales of both detergents and soaps increased by almost 8 per cent: From $691,000,000 in 1952 to $745,800,000 in 1953.

The product showing the most ambitious growth was liquid synthetic detergents for household use, although it is still a very small fraction of total sales. In 1953, 94,600,000 lb were sold, whereas five years ago it was practically unknown. This product increased almost 91 per cent over 1952.

### Synthetic Anhydrous Ammonia

Although synthetic anhydrous ammonia is not a synthetic organic chemical, it is generally considered a petrochemical when it is manufactured from synthesis gas (made from natural gas), petroleum refinery gas, or from by-product hydrogen.

By the end of 1953, close to 80 per cent of production was from natural gas compared to 8 per cent in 1940. For the two year period (1953-1955), 27 new plants came or are expected to come on stream. During the last 15 months, over 1600 tons of daily capacity was built. Within the following 18 months, an even 3000 tons of daily capacity is scheduled to be constructed.

Capacity appeared to be somewhat in excess of demand for certain forms of ammonia and in certain areas, while in others, some shortages existed. During December, 1953, the industry was producing at an annual rate of about 2,400,000 tons. Agriculture, the heaviest user of ammonia and consuming about 78 per cent of production in 1953, is still increasing its demand at the rate of about 150,000 tons a year. For the first six months of 1954, however, agricultural orders have been so heavy that the Agriculture Ammonia Institute predicts a shortage for the second quarter of 1954.

Industry is also increasing its demand by 25-50,000 tons, but military purchases have declined, by about 300,000 tons a year. From construction plans, it would appear that producers are confident that the present and near future overproduction is mainly a matter of a few months or a year before the economy can absorb the output. In some areas in 1953, demand has actually exceeded the available supply — a difficulty due more to transportation than to production.

**Synthetic anhydrous ammonia in millions tons.**

| Year | |
|---|---|
| 1948 | 1.08 |
| 1949 | 1.29 |
| 1950 | 1.56 |
| 1951 | 1.76 |
| 1952 | 2.05 |
| 1953 (estimated) | 2.40 |
| 1954 (estimated) | 2.90 |
| 1955 (estimated) | 3.50 |

**Synthetic ammonia plants coming on stream**

January 1953—March 1954

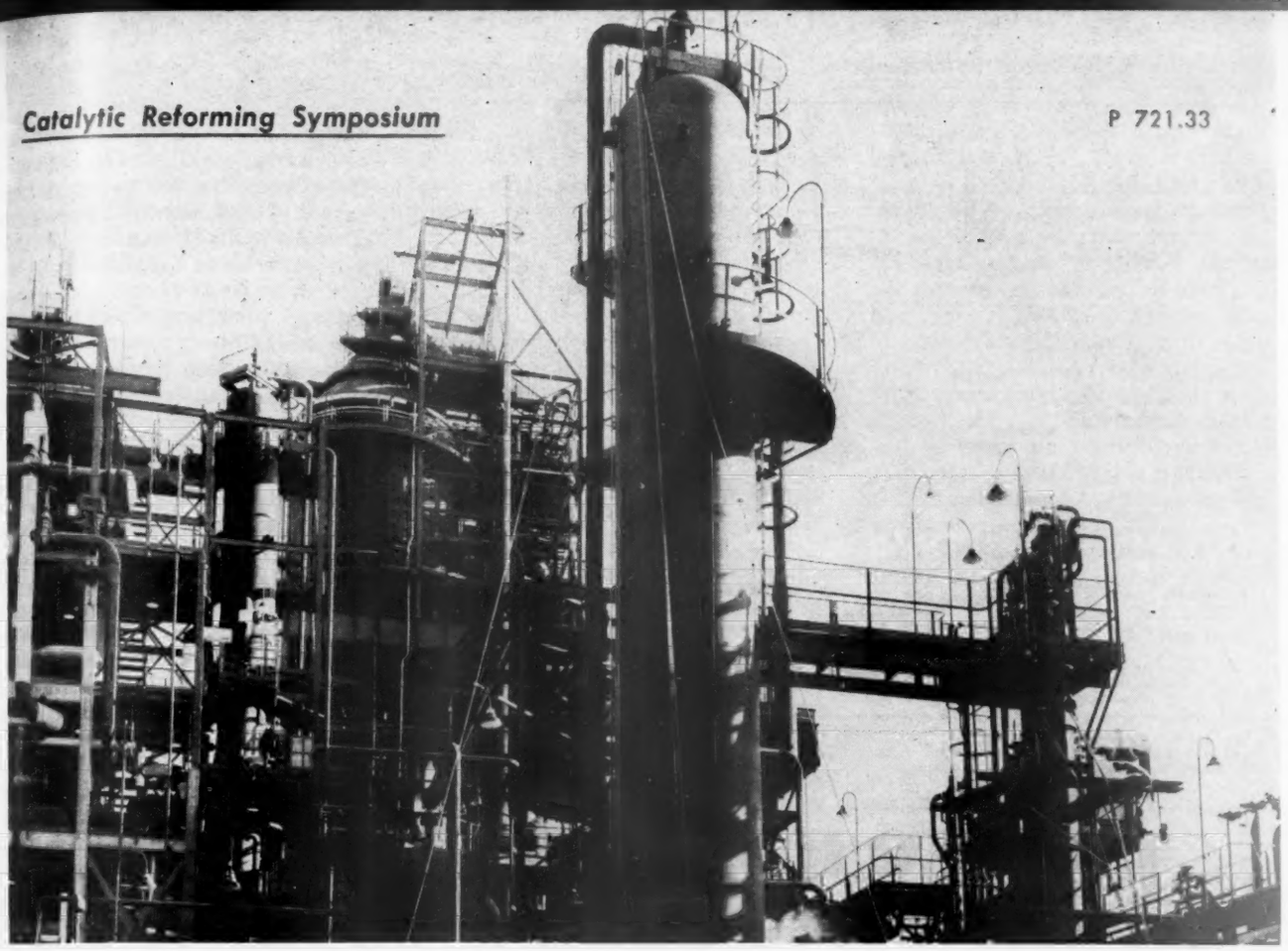
| | | |
|---|---|---|
| Allied Chemical & Dye | Hopewell, Va. | 150 T/D |
| | South Point, O. | 150 T/D |
| Brea Chemicals, Inc. | Brea, California | 150 T/D |
| Commercial Solvents | Sterlington, Cal. | 200 T/D |
| Mathieson | Lake Charles, La. | 60 T/D |
| Mississippi Chemical | Yazoo City, Miss. | 60 T/D |
| Pennsalt | Wyandotte, Mich. | 55 T/D |
| Phillips Chemical Co. | Adams Terminal | 450 T/D |
| Shell Chemical Corp. | Ventura, Calif. | 150 T/D |
| Spencer Chemical Co. | Vicksburg, Miss. | 210 T/D |

**Synthetic ammonia plants 1954—1955**

| | | |
|---|---|---|
| Allied Chemical & Dye | La Platte, Neb. | 214 T/D |
| American Cyanamid | Fortier, La. | 300 T/D |
| Chillicothe Chemical | Chillicothe, Tex. | 180 T/D |
| Atlantic Refining | Point Breeze, Pa. | 100 T/D |
| Commercial Solvents | Sterlington, La. | 100 T/D |
| Columbia Southern | Natrium, W. Va. | 100 T/D |
| Cooperative Farm Chemical | Lawrence, Kansas | 150 T/D |
| Deare | Pryor, Oklahoma | 180 T/D |
| Dow Chemical | Freeport, Texas | 100 T/D |
| Grace Chemical | Memphis, Tenn. | 250 T/D |
| Hooker Electrochemical | Tacoma, Washington | 20 T/D |
| Lion Oil | Luling, La. | 300 T/D |
| Mill Creek Chemical | Salt Lake City | 180 T/D |
| National Petro-Chemicals | Tuscola, Ill. | 150 T/D |
| San Jacinto Chemical | San Jacinto, Texas | 40 T/D |
| Utah Chemical | Nephi, Utah | 270 T/D |
| Northern Chemical Industries | Sears Port, Maine | 150 T/D |
| Salt Lake City Chemical | Salt Lake City, Utah | 180 T/D |

Some changes of importance are occurring. Brea Chemical, for example, is shipping aqua ammonia for use in the extensive irrigation systems of Hawaii. High hopes are held for greater use of this fertilizing method; should they come true, the West Coast should sell its greatly increasing production. Shell Chemical plans to ship anhydrous ammonia under pressure in a 1680 ton barge from Pittsburg, California, to Oregon and Washington, a 900-mile sea route. The northeastern section of the country is not being overlooked: Northern Chemical Industries is about to build a 150 ton per day plant at Sears Port, Maine.

The first commercial installation using the Texaco Development-Hydrocarbon Research partial oxidation process to make synthesis gas for ammonia production has now been sufficiently long in operation for Spencer Chemical engineers to know that the 6 per cent reduction claimed for operating costs may actually work out that way in practice. Reported so far are a 15 per cent saving in natural gas for raw material and fuel, a two-thirds reduction in the number of operators because of automatic controls, and the elimination of one distillation step, as the ammonia is essentially pure anhydrous ammonia. ★ ★ ★




**Catforming unit of Atlantic Refining at its Philadelphia refinery has capacity of 500,000 gal of high octane gasoline daily.**

# GREATEST TECHNOLOGICAL ADVANCE SINCE WAR

## *Rebuilding of molecular structure of low-grade naphthas solves problem of better motor fuels, petrochemicals*

Upgrading of low-quality naphthas has been a potential, often actual headache for refiners ever since the phenomenon of detonation, or knocking became important in our rapidly improving automobile engines. Strangely enough, it was a major depression and the need for boosting gasoline sales in a "sick" market that pushed ahead the development of thermal reforming, a process that lagged well behind thermal cracking of heavy oils. Thermal reforming came to the fore in the early 1930's.

**EXCLUSIVE**

After the introduction of cat cracking, refiners found their path of progress in improving anti-detonation properties of motor fuels blocked partially by the presence of the same low-grade naphthas, that could not be improved enough by thermal methods. Even before the war the pioneer catalytic Hydroforming process, fixed-bed style, was employed by a half-dozen refiners to improve naphthas. One all-important side line was the formation of aromatics, segregated during the war as intermediates for aviation fuel, explosives, etc.

Now at least nine catalytic reforming processes are available and either employed in operating units or such units are in process of construction, in this country. The British Catarole process has not been included here as it appears to be primarily for chemical intermediates production rather than for improving motor and aviation fuel qualities.

In the following pages each of these processes is discussed in condensed but fairly adequate detail to give readers the essential principles and operating methods, as well as the yields, qualities, and properties of the various products made by each process. In these brief pages are found the most complete though condensed discussions of the salient facts in cat reforming yet made available in the literature.

The far-reaching effect of cat reforming on the aviation and motor fuels industry, on petrochemical intermediates and that entire industry cannot be overestimated. The only possible advantage cat cracking possesses over reforming is that of producing more hydrocarbons in the gasoline boiling range that do not exist before being cat cracked. Cat reforming adds more to the octane balance, and also outstrips cat cracking in the synthesis of chemicals and intermediates. This symposium is a condensed cyclopedia of cat reforming in 1954.

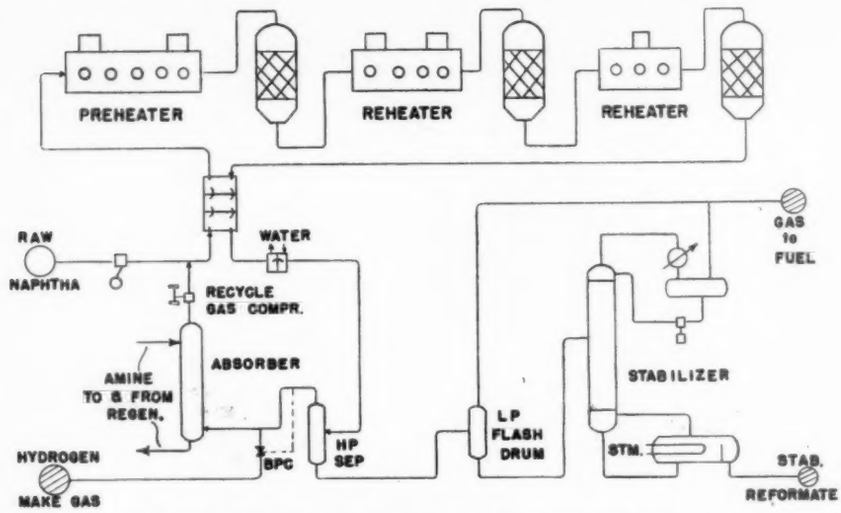



FIG. 1. Schematic flow diagram of Husky Oil Catformer.

# CATFORMING

## *Gasoline yield of 70 bbl per pound of catalyst obtained in units operating currently*

**DAVID C. BENEDICT***

NOW in its second year of commercial operation, Atlantic Catforming has demonstrated its unusual ability to process a wide variety of feed stocks without special treatment of any kind. Units now in operation charge a variety of feeds ranging from sour light distillate to heavy middle-East naphtha. Among the Catformers that went on stream in 1953 was the Husky Oil Company 1000 bbl per day unit which processes high-sulfur Wyoming stocks. Also The Atlantic Refining Company's own 11,000 BPD Catformer in Philadelphia started in December and has since run naphthas from Middle East, Venezuelan, and domestic crudes.

### Husky Catformer Exceeds Guarantees

The Catformer of the Husky Oil Company at Cody, Wyoming, charges a mixture of naphtha produced from Oregon Basin, a high-sulfur asphalt crude, and Golden Eagle, a high-sulfur light crude distillate. Produced as an overhead cut in a two-stage distillation unit, the entire full-boiling range naphtha is charged to the Catformer, the product from which constitutes the sole source of gasoline inasmuch as the refinery has no cracking facilities of any kind. From this stock various competitive grades of gasoline are produced by operating the Catformer at different severity levels. Severity can be varied as desired simply by changing reactor inlet temperatures. The Catformate may then be sent directly to the appropriate blend tank for making either regular or premium gasolines. The addition of natural gasoline for vapor pressure, tetraethyl lead, and dye completes the normal blending procedure. Test run data are given in Table 1.

Regular gasoline is produced at yields of 101.9 per cent (10 lb RVP), while producing reformate of 85.8 octane with 2cc of lead from a 52 octane charge mixture. The product from the unit is virtually sulfur-free.

Prior to installation of the Catformer, Husky's practice was to clay desulfurize and copper sweeten the crude naphtha, and purchase high octane blend stocks in order to meet octane specifications. Gasoline thus produced still had a fairly high sulfur content which affected lead susceptibility adversely, and had poor odor characteristics. This new gasoline is clean, very low in sulfur, improved in odor, higher octane, and makes them independent of outside suppliers of cracked stocks. Consumer response to the improved gasoline has been very favorable. Performance has exceeded all process guarantees including yield-octane and catalyst life.

### McBride Unit On Way to Record Run

The Catformer of the McBride Refining Company, first Catformer to go on stream is currently at a catalyst life above 70 bbl per pound and is on its

TABLE 1.

| | Charge | Product |
|---|---|---|
| Gravity °API | 62.6 | 62.6 |
| % Sulfur | 0.10 | 0.001 |
| RVP | 8.1 | 12.0 |
| ASTM Over | 95 | 87 |
| End Point | 370 | 385 |
| Octane CFRR Clear | 54.0 | 80.6 |
| 3cc | 72.4 | 94.6 |
| Yield - $C_4$ Plus, Vol. % | 95.5 | |

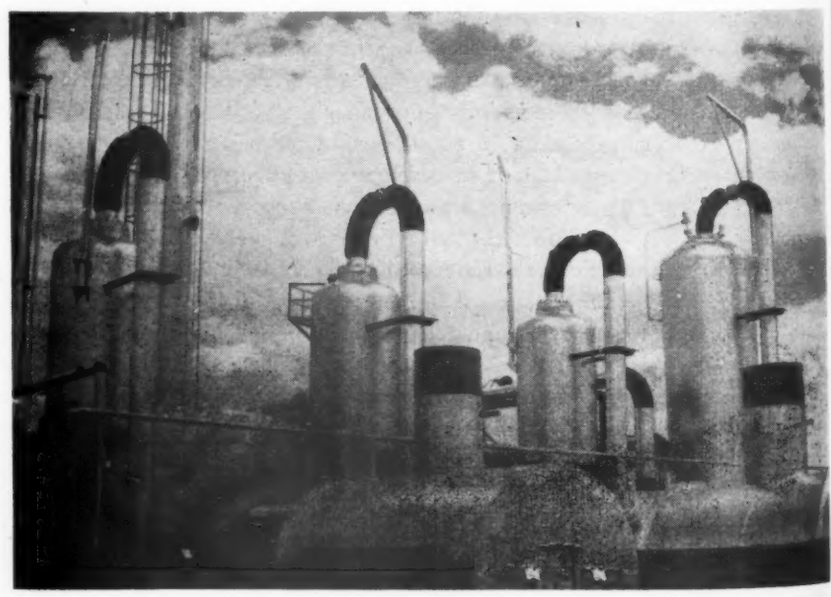


FIG. 2. Catformer unit installed at plant of Husky Refining Company, Cody, Wyoming.

*Chemical engineer, research and development department, Atlantic Refining Company.

way to a record run. This unit, which has been described previously[1], performed above specification levels since the first day it went on stream and exceeded guaranteed catalyst life on every batch of catalyst beginning with the initial charge. The Malco Refineries' Catformer, also described in earlier literature[2], completed its initial run with a catalyst life of 70 bbl/lb.

The ability to handle these stocks so successfully means that refiners now have a relatively simple way of keeping abreast with competitive octanes. With the recent octane increases many refiners find they can no longer obtain the desired results by selective blending of high octane components, but must upgrade every stream going into gasoline. These may be low octane straight-runs, thermally cracked naphthas, distillates, or natural gasolines. An Atlantic Catformer can charge any or all of these stocks without any changes in process equipment. No feed pretreatment is required to remove water, sulfur, nitrogen compounds, or contaminants such as arsenic in the amounts normally found in refinery stocks. This makes an Atlantic Catformer unmatched for simplicity, which means lowest investment and operating costs for the refiner. In contrast with the increasing complexity of modern refining equipment, Catforming stands out as the process that does a complete job with simple equipment and a minimum of attention.

### Features of Husky Unit

From the crude fractionator overhead accumulator the naphtha is caustic washed to remove hydrogen sulfide and water washed en route to run down tankage. From there the raw naphtha, saturated with water and containing about 0.1 per cent sulfur, is charged directly to the Catformer. No desulfurization, prefractionation, or drying of the feed is employed. The incoming naphtha is mixed with a recycle hydrogen stream, heated to reaction temperature, and passed over catalyst in fixed beds. (See Fig. 1). Because the net heat effect of the various reactions is endothermic, it is necessary to reheat the reaction mix between the catalyst beds. Following the last reactor the naphtha is condensed and separated from the recycle gas. The recycle gas is 90-97 per cent hydrogen, a result of the high selectivity of Atlantic catalyst which produces very little methane or ethane. Excess hydrogen produced in process is withdrawn from separator and used for processing elsewhere in refinery.

Naphtha is stabilized in a conventional tower to obtain the desired vapor pressure, and is then blended into finished gasoline without further treatment. Sulfur in the feed stock is converted to hydrogen sulfide in the reactors and leaves the process as a gas. Because of the relatively high sulfur content of the feed stock, hydrogen sulfide is scrubbed from the recycle gas to avoid cycling large quantities back through the process. A conventional bubble-cap absorber is employed for this purpose using an aqueous monoethanolamine solution as the absorbent. The scrubbed recycle gas leaving the absorber usually contains less than five grains of hydrogen sulfide per hundred cubic feet of gas. It is not necessary to water wash, dry, or otherwise treat the scrubbed recycle gas since, again, water and nitrogen compounds do not harm the catalyst.

The reaction section of the unit consists of three reactors of equal size made of carbon steel outer walls, stainless steel inner lining with insulation between the two metal shells. Three separate furnaces are provided for preheat and reheat between reactors, all being gas-fired, horizontal radiant-heat type.

The high pressure exchange section is a bank of fin-tube exchanger units manifolded together. The naphtha feed pump is a constant speed duplex electrically driven. Flow control is accomplished by by-passing naphtha from the discharge back to the suction. Recycle gas compressors on this unit have carbon rings and packing and are nonlubricated, although several other units now in operation employ standard lubricated compressors. Drive is by gas engines through clutch and V-belt, with governor speed control on the engine. Operation of the unit requires the partial attention of one man who also operates a second unit.

Design and construction of the unit was by the Grebe & Doremus Process Company of Houston, Texas.

### Reference


1. First Commercial "Catforming" Unit on Stream at McBride Refinery, C. S. Faulkner, B. E. Milner, H. A. Grebe—O. & G. J., November 24, 1952.
2. A Look at Commercial Catforming, H. R. Grane—Petroleum Refiner, September, 1953.


# CYCLOVERSION

## *Multi-purpose process: Desulfurization, reforming of straight-run naphthas, catalytic cracking of heavier oils*


**O. D. EDWARDS***

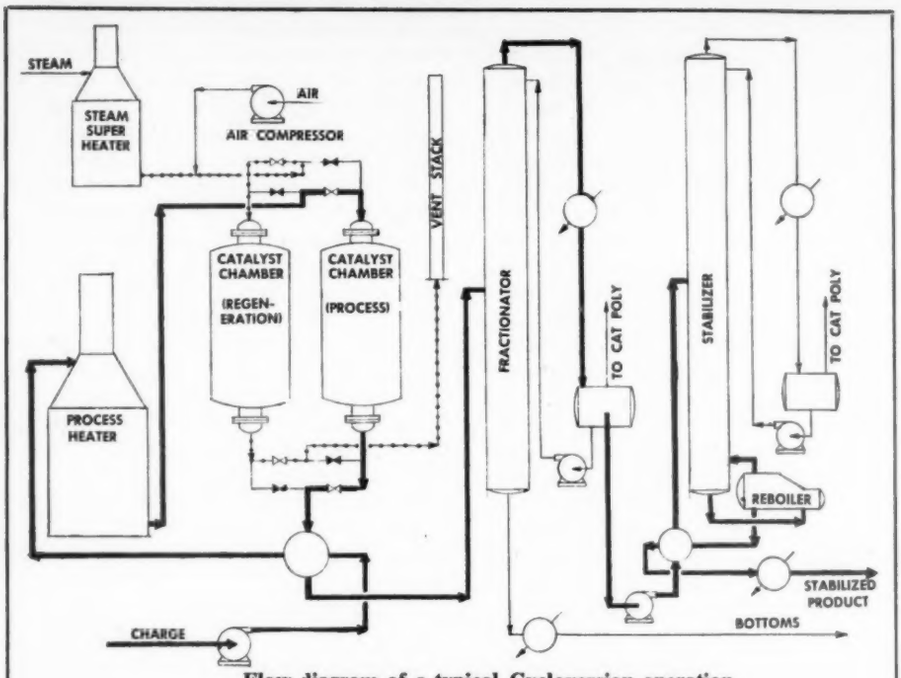

THE catalytic process called Cycloversion is employed in three types of refining service: (1) desulfurization of straight run and cracked gasolines, kerosine, and diesel fuel; (2) reforming of straight run gasoline or naphtha; and (3) cracking of gas oil for the production of high-octane gasoline.


*Phillips Petroleum Company.


When operated as a catalytic desulfurizer, the Cycloversion unit effects no appreciable change in the feed stock other than to decrease its sulfur content, thereby improving the lead susceptibility of gasoline so treated. Physical properties of the feed stock, such as vapor pressure, gravity and boiling range, remain essentially con-

**TABLE 1. Perco catalytic desulfurization.**

| Crude source | Poza Rica Straightrun gasoline | | East Texas Cracked gasoline | | Western Canada Diesel fuel | |
|---|---|---|---|---|---|---|
| Feed stock | Charge | Product | Charge | Product | Charge | Product |
| Operating conditions: | | | | | | |
| Feed rate, bbl per day | 15,000 | — | — | — | — | — |
| Space velocity, vol/vol/hr | 2.1 | — | 1.22 | — | 1.0 | — |
| Top catalyst temperature, deg F | 800 | — | 758 | — | 750 | — |
| Catalyst chamber pressure, psig | 75 | — | 35 | — | 50 | — |
| Gasoline yield, vol per cent of charge | — | 98.8 | — | | — | — |
| Inspection data: | | | | | | |
| Gravity, °API at 60 F | 66.5 | 65.7 | 58.3 | 58.0 | 34.5 | 35.1 |
| RVP, psig at 100 F | 6.1 | 5.4 | 7.3 | 7.4 | — | — |
| Total sulfur, wt. per cent | 0.079 | 0.012 | 0.415 | 0.270 | 0.72 | 0.35 |
| ASTM distillation, deg F | | | | | | |
| I.b.p. | 111 | 105 | 97 | 97 | 291 | 221 |
| 10 vol per cent | 142 | 137 | 144 | 144 | 404 | 395 |
| 30 vol per cent | 178 | 184 | — | — | 442 | 438 |
| 50 vol per cent | 222 | 228 | 255 | 254 | 476 | 473 |
| 70 vol per cent | 266 | 271 | — | — | 512 | 509 |
| 90 vol per cent | 315 | 318 | 348 | 351 | 563 | 558 |
| End point | 359 | 359 | 394 | 422 | 614 | 628 |
| Recovery, vol per cent | 98.5 | 98.5 | — | — | 98.0 | 98.0 |
| Research octane number | | | | | | |
| Clear | 40.7 | 46.7 | 72.2 | 75.4 | — | — |
| + 1 ml TEL per gal | 51.0 | 60.2 | 77.7 | 82.0 | — | — |
| + 3 ml TEL per gal | 62.3 | 72.5 | 82.8 | 86.9 | — | — |




**Flow diagram of a typical Cycloversion operation.**

**TABLE 2. Perco catalytic reforming of straightrun gasoline.**

| | Mid-Continent | | East Texas | | Texas Panhandle | |
|---|---|---|---|---|---|---|
| Crude source | Charge | Product | Charge | Product | Charge | Product |
| Operating conditions: | | | | | | |
| Feed rate, bbl per day | 657 | — | 650 | — | 13,500 | — |
| Space velocity, vol/vol/hr | 0.66 | — | 1.0 | — | 1.78 | — |
| Top catalyst temperature, deg F | 950 | — | 1015 | — | 1,000 | — |
| Catalyst chamber pressure, psig | 50 | — | 50 | — | 85 | — |
| Gas make, cu ft per bbl | 115 | — | — | — | — | — |
| Yield summary, per cent of charge: | | | | | | |
| Gasoline, vol per cent | — | 95.5 | — | 83.5 | — | 90.0 |
| Gas and loss, wt. per cent | — | 4.5 | — | — | — | — |
| Inspection data: | | | | | | |
| Gravity, °API | 62.9 | 61.7 | 51.4 | 53.2 | 54.0 | 54.8 |
| RVP, psig at 100 F | 8.4 | 6.5 | 1.0 | 4.5 | 1.0 | 2.2 |
| Total sulfur, wt. per cent | — | — | 0.013 | 0.005 | 0.090 | 0.009 |
| ASTM distillation, deg F | | | | | | |
| I.b.p. | 115 | 114 | 170 | 117 | 222 | 154 |
| 10 per cent | 168 | 160 | 257 | 210 | | |
| 30 per cent | 208 | 208 | 285 | 254 | | |
| 50 per cent | 238 | 236 | 310 | 297 | | |
| 70 per cent | 267 | 266 | 345 | 309 | | |
| 90 per cent | 312 | 322 | 412 | 353 | 346 | 334 |
| End point | 376 | 378 | 475 | 427 | 408 | 402 |
| Recovery, vol per cent | 99 | 95 | 97.0 | 98.0 | | |
| Research octane number | | | | | | |
| Clear | 49.8 | 60.1 | 41.5 | 65.3 | 38.4 | 57.0 |
| + 1 ml. TEL per gal | 62.6 | 70.4 | 51.7 | 74.0 | — | — |
| + 3 ml. TEL per gal | 74.5 | 80.2 | 67.0 | 81.5 | 57.3 | 71.4 |

**TABLE 3. Cycloversion gas oil cracking.**

| | Illinois Virgin gas oil | | West Texas-Wyoming Virgin gas oil | |
|---|---|---|---|---|
| Crude source<br>Feed stock | Charge | Product | Charge | Product |
| Operating conditions: | | | | |
| Feed rate, bbl per day | 600 | — | 3700 | — |
| Space velocity, vol/vol/hr | 1.0 | — | 0.62 | — |
| Top catalyst temperature, deg F | 965 | — | 965 | — |
| Catalyst case inlet pressure, psig | 40 | — | 58 | — |
| Catalyst case outlet pressure, psig | 39 | — | 54 | — |
| Steam, wt. per cent of charge | 10.0 | — | 10.0 | — |
| Yield summary, per cent of charge: | | | | |
| Gasoline, vol per cent | — | 34.0 | — | 33 |
| Distillate, vol per cent | — | 44.0 | — | 27 |
| Bottoms, vol per cent | — | 17.5 | — | 32 |
| Gas, wt. per cent | — | 10.8 | — | 7.8 |
| Total liquid recovery, vol per cent | — | 95.5 | — | 92.0 |
| Inspection data: | | Gasoline | | Gasoline |
| Gravity, °API at 60 F | 32.7 | 56.8 | 28.1 | 59.2 |
| RVP, psig at 100 F | — | 10.9 | — | 12.0 |
| I.b.p., deg F | 445 | 101 | 434 | — |
| End point, deg F | 90% 854 | 436 | 670 | 396 |
| Pour point, deg F | +60 | — | +60 | — |
| Flash point, deg F | — | — | 186 | — |
| Total sulfur, wt. per cent | 0.15 | 0.013 | 1.75 | — |
| Octane number | | | | |
| Motor method, 3 ml. TEL | — | — | — | 79.0 |
| Research method, 3 ml. TEL | — | 95.7 | — | 92.0 |
| | | Distillate | | Distillate |
| Gravity, °API | — | 33.5 | — | 33.5 |
| I.b.p., deg F | — | 347 | — | 410 |
| Pour point, deg F | — | +5 | — | Below —20 |
| Flash point, deg F | — | — | — | 192 |
| Color NPA number | — | — | — | 2¾ |
| | | Bottoms | | Bottoms |
| Gravity, deg API | — | 28.8 | — | 16.1 |
| I.b.p., deg F | — | 460 | — | 538 |
| Pour point, deg F | — | +55 | — | 30+ |
| Flash point, deg F | — | — | — | 230+ |

stant, indicating that no undesirable side reactions occur in the process. Reduction of sulfur content is accomplished by converting the sulfur to hydrogen sulfide. The improvement in gasoline octane numbers resulting from catalytic desulfurization is further enhanced, for cracked gasoline feed, by isomerization. The total refinery production of cracked gasoline and straight run gasoline is often combined as a mixed feed to the desulfurization unit. Processing of diesel fuel for sulfur reduction has increased in the past few years.

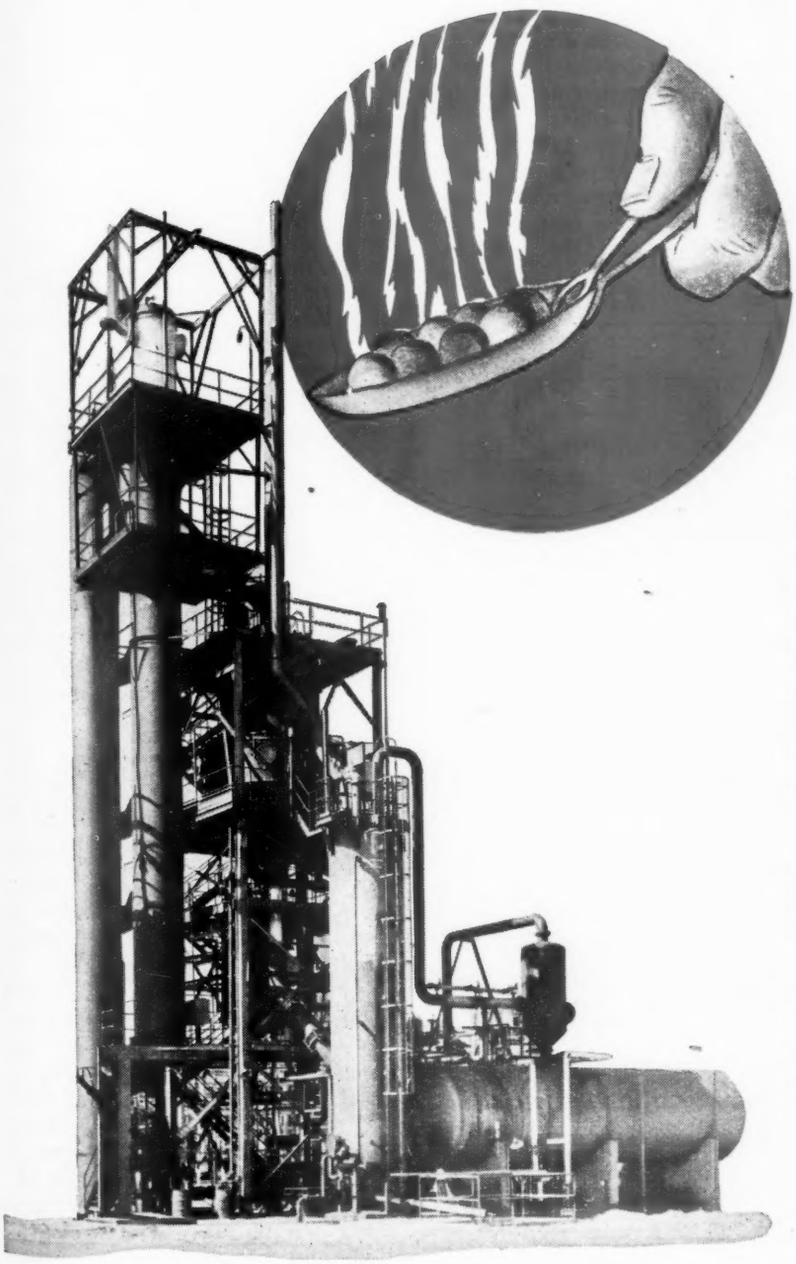
Catalytic reforming accomplishes not only the effect of desulfurization but also an increase in both clear and leaded octane numbers of the gasoline, the degree of increase being dependent upon the severity of reforming.

Catalytic cracking in the Cycloversion unit is applied to clean gas oils having a boiling range of 400-800 F. In addition to high octane motor fuel, the products of gas oil cracking include highly olefinic gases, low pour point recycle stocks, and bottoms.

A Cycloversion unit is of conventional design and contains the basic equipment shown in the flow diagram. To permit continuous operation, two reaction chambers are provided. Feedstock is being processed through one chamber while the catalyst is being regenerated in the other chamber. The catalyst is regenerated in situ and the steam superheater, air compressor and vent stack are incorporated for this purpose. As the same catalyst is used for all the listed applications of Cycloversion, a unit containing the equipment shown in the flow diagram can perform any of the operations. Generally, fractionation and stabilization facilities are not required for desulfurization of straight run gasoline or naphtha, and this equipment may be omitted in the event that only desulfurization of these materials is specified. Also, in these instances a single reactor is provided, which permits the process heater to serve as steam superheater during regeneration of the catalyst. Where regeneration facilities are not incorporated in the Cycloversion process, the reactor is dumped and refilled with new catalyst when it has become sufficiently inactive and is no longer effective in reducing the sulfur content to the desired level.

For gas oil cracking or reforming, all the equipment shown on the flow diagram is suggested. As the rate of carbon deposition is considerably higher for either of these operations or for diesel fuel desulfurization, the process cycles are shorter and non-regenerative units are not practical. Process periods vary from 3 to 12 hours for gas oil processing and from 12 to 72 hours for

# Hottest New Idea from PERCO*



**PEBBLES,** like these, heated to very high temperatures, are used for cracking light hydrocarbons to produce ethylene.

The Pebble Heater is an apparatus for attaining temperatures beyond the range of conventional tube furnaces. Continuously circulating refractory balls (called pebbles) are heated by combustion gases by direct contact. The hot pebbles flow downward into a reaction chamber where they are contacted directly by the charge material.

Phillips Petroleum Company is currently operating a new 30 MM Btu/Hr Pebble Heater at ethane conversions of 90% and above.

The Pebble Heater is not limited to hydrocarbon processing but has wide application to superheating steam or air and the processing of corrosive materials.

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## PHILLIPS PETROLEUM COMPANY

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reforming or diesel fuel desulfurization. To remove the $H_2S$ formed by decomposition of the sulfur compounds, caustic washing is generally provided. No further treatment is necessary although inhibitors are required for stabilization of gasoline from gas oil cracking or deep reforming operations.

The catalyst is Cyclocel grade bauxite and is a naturally occurring material. A catalyst life of 5000-20,000 bbl per ton is generally realized in non-regenerative units. This life is extended to 50,000-100,000 bbl per ton of catalyst in regenerative units.

Temperature, pressure, and space velocity are the major process variables. The conversion depth is increased by raising the temperature of operation, which is accompanied by more rapid deactivation of the catalyst. Olefin content of the gasoline obtained from gas oil cracking is increased at low pressures, resulting in an increase of its octane rating. An increase in space velocity at constant temperature and pressure decreases the depth of conversion.

Desulfurization yields vary from 98.0-99.5 liquid volume per cent of the charge. Reforming and gas oil cracking yields are dependent on the severity of the operation. Gas oils are generally processed to effect a 50 per cent conversion of the charge. The tables on C-16 show typical operating data and charge-product inspection tests for the three types of operation discussed.

The first Cycloversion unit was installed in 1940. Thirty-nine units now in operation in the United States, Canada, Mexico and Europe have a total design capacity of approximately 130,000 bbl per day. These units range in size from 300-18,000 bbl daily capacity. * * *

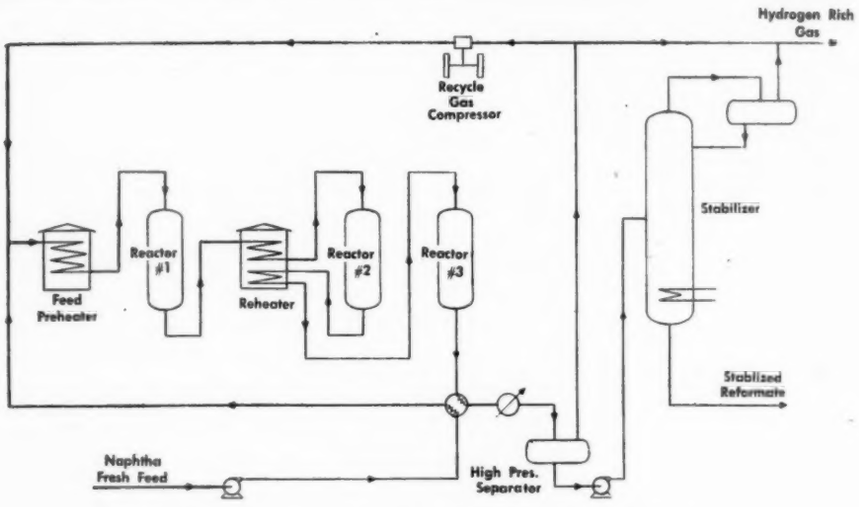



FIG. 1. Diagrammatic flow of Houdriforming process.

# HOUDRIFORMING

*Higher octane number fuels, large aromatics yields, high-purity hydrogen byproduct characterize this process*

R. E. BLAND*

HOUDRIFORMING is a continuous catalytic reforming process which utilizes a platinum catalyst for the conversion of straight-run and cracked petroleum naphthas to high-octane motor gasoline, aviation blending stocks and aromatics.

With Sun Oil Company's 15,000 bbl-per-day Houdriformer going on stream in 1953, and 42,000 bbl of additional capacity being engineered and constructed, Houdriforming is well established as a leading catalytic reforming process.

*Houdry Process Corporation.

### Salient Features of Houdriforming

1. The process can reform efficiently a variety of charging stocks differing widely in boiling range and chemical composition. Naphthas with end boiling points up to 400 F may be processed.

2. Low octane straight-run naphthas are upgraded as much as 40-70 octane numbers with high liquid volume recovery. At the same time almost complete desulfurization of the charge is realized. Stabilized reformates require no additional treatment before blending in the refinery-finished gasolines.

3. Houdriforming straight-run naphthas to produce aromatics results in the conversion of naphthenes to aromatics at yields up to 100 per cent of theoretical values. In addition, aromatization of paraffins proceeds to a significant extent.

4. Under normal conditions of operation for either motor gasoline or aromatics, catalyst activity is maintained for long periods without regeneration; therefore, Houdriforming is a truly continuous process. If called upon to perform under extremely severe conditions where catalyst activity is reduced by carbon deposition, the catalyst can be regenerated in situ. The regeneration removes catalyst deposit and restores the catalyst activity and selectivity.

5. High purity hydrogen is produced as a by-product. When operating for aromatics, hydrogen of 95+ per cent purity is produced. Large volumes of hydrogen of 85 to 90 per cent purity are produced from motor gasoline operations and are recoverable for use in other processes.

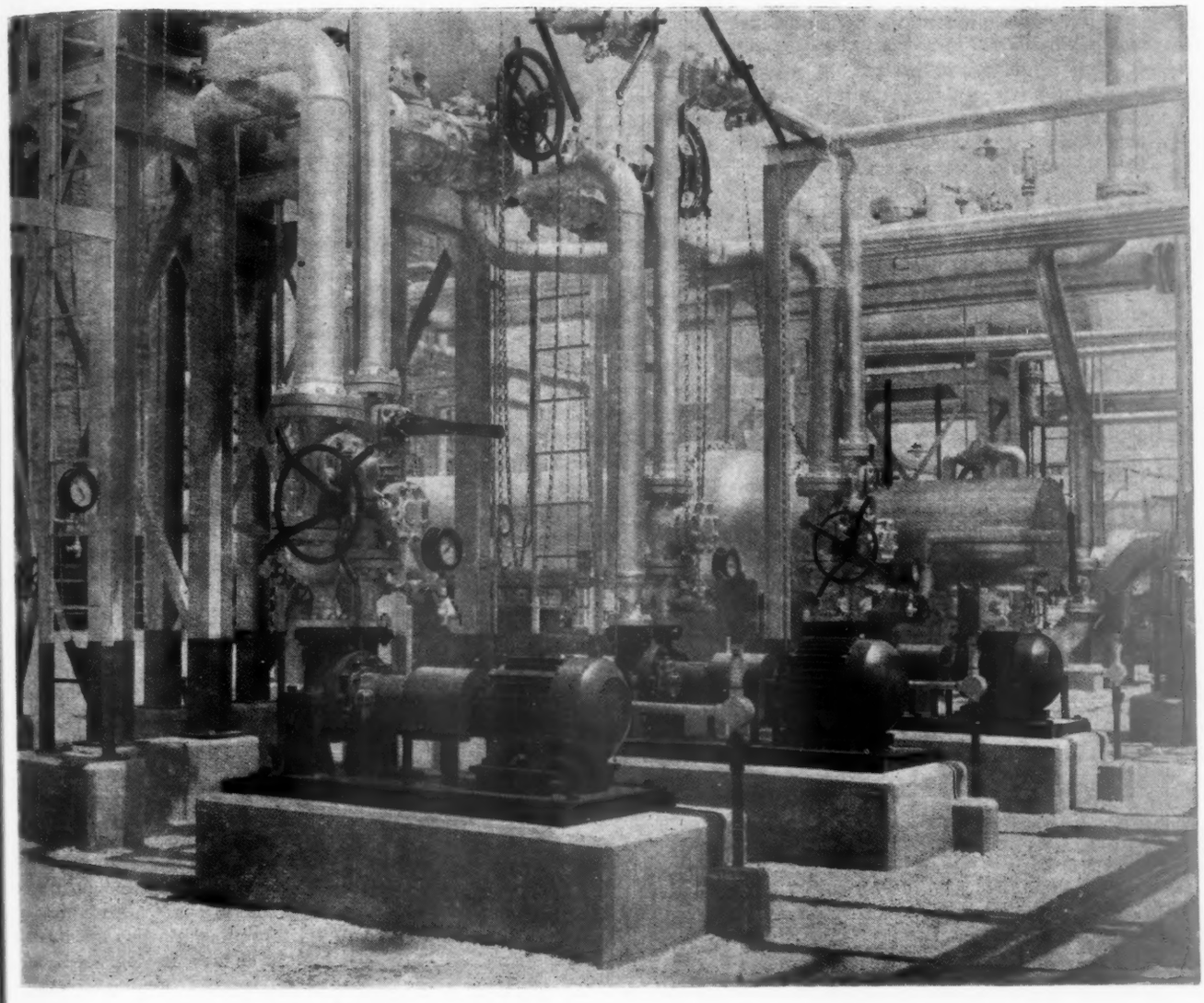
### Houdriforming Catalyst

The catalyst used in Houdriforming is a platinum catalyst designated as Houdry Type 3. It is manufactured by Houdry Process Corporation at Paulsboro, New Jersey, in a commercial plant that was placed in operation in 1952.

In Houdriforming operations this catalyst promotes reactions which consist predominantly of dehydrogenation, isomerization, aromatization, hydrocracking, and desulfurization. Dehydrogenation and dehydroisomerization of naphthenes promote the formation of aromatic concentrates such as benzene, toluene, and xylenes from naphthene-rich fractions. The same reactions plus isomerization and aromatization of paraffins produce high yields of high-octane motor gasoline from straight-run naphthas.

Houdry Type 3 catalyst is compounded to fulfill the exacting requirements of catalyst strength, activity, and selectivity for catalytic reforming operations. It is well balanced to carry out the several types of reactions enumerated above for processing a variety of charging stocks differing widely in

# at 3-BAR GAS INJECTION & GASOLINE PLANT



**Ingersoll-Rand SFLA Pumps** meet a wide range of processing requirements at this Andrews, Texas plant operated by Stanolind Oil and Gas Company. The three 1½" SFLA units shown above are on debutanizer and depropanizer reflux service, handling 128 gpm of 90°, .55 sp. gr. reflux at 52 psig suction and 102 psig discharge. Other similar I-R pumps at this plant are used for still reflux, scrubber condensate and caustic mix services. The totally enclosed design of the rugged SFLA line, with integral mechanical shaft seal, assures maximum safety and dependability in refinery and process services.

Ingersoll-Rand, Cameron Pump Division, 11 Broadway, New York.

981-10



XUM

chemical composition in such a highly selective manner that undesirable side reactions are suppressed. As a result, exceptionally high yield-octane results consistent with long catalyst life and maintenance of catalyst activity and selectivity are realized.

### Charge Stocks

For motor gasoline operation, naphthas which contain 400 F material may be charged, with the initial boiling points varying anywhere between 180 F and 300 F. The actual feed stock selected for any given plant will depend on a number of factors such as reforming capacity available, octane level of over-all refinery gasolines and economic considerations.

Charge stocks for aromatics production are fractionated to include those naphthenes that are converted to benzene, toluene, xylenes, and, if desired, higher boiling aromatics. Because of thermodynamic considerations, optimum yields of aromatics are obtained by running closely cut fractions resulting in the formation of only one or two aromatic compounds. However, economic considerations may favor an operation in which a mixture of aromatics is produced, at slight sacrifice in yield.

Naphthas charged to Houdriforming for either motor gasoline or aromatics production should be substantially free of metals such as lead, nickel, copper, arsenic, etc., since these materials permanently impair the catalyst activity. Likewise, protection against excess water and oxygen or oxygenated compounds should be provided. High sulfur stocks can be processed without difficulty provided a means is provided for eliminating $H_2S$ from the recycle hydrogen gas, or preferably from the fresh feed before charging to the reactors. A simple, efficient pretreating system is available with Houdriforming for the removal of sulfur and all of the other catalyst contaminants enumerated.

### Typical Performance Data

Naphtha feed stocks have been evaluated from a great many foreign and domestic crude oils covering the extremes in physical and chemical properties that normally will be encountered. Typical yield-octane data from Houdriforming to produce motor gasolines are presented in Tables 1 and 2. Those naphthas shown in Table 1 were selected to show the influence of chemical composition on yields. Paraffin contents vary from 31 per cent to 64 per cent. Yields on each stock are shown for two reforming severity levels. Naphthas low in paraffin content are mostly easily converted to a given octane level because the initial octane is higher as a result of the higher content of naphthenes plus aromatics. Also naphthenes respond more readily to reforming than paraffins. Naphtha derived from natural gas condensate also provides a suitable charge to Houdriforming and offers a welcome solution to the problem of effectively using larger quantities of this material in motor gasolines at the present elevated octane levels. Although the natural gas condensate shown in Table 2 has a F-1 clear octane of only 24.6 and contains 77 volume per cent of paraffins, it can be reformed to obtain a yield of 88 volume per cent of 10 lb RVP reformate having F-1 octanes of 83 clear or 95 with 3cc of TEL.

Tables 3 and 4 present typical results obtained in the production of aromatics. Yields are shown for processing a $C_6$-$C_7$ fraction for benzene-toluene production, as well as yields of $C_8$ aromatics produced from a $C_8$ straight-run naphtha.

**TABLE 2. Processing 230-394 F, paraffinic naphtha from natural gas condensate.**

| | A | | B | |
|---|---|---|---|---|
| | Wt. % | Vol. % | Wt. % | Vol. % |
| Yields | | | | |
| Debutanized gasoline. | 80.1 | 78.1 | 83.2 | 80.8 |
| Total $C_4$ | 7.6 | 9.9 | 7.1 | 9.2 |
| Total $C_3$ | 6.9 | | 5.2 | |
| Total $C_2$ | 3.0 | | 2.3 | |
| Total $C_1$ | 1.5 | | 1.1 | |
| Total $H_2$ | 0.9 | | 1.1 | |
| | 100.0 | | 100.0 | |
| Stabilized gasoline (10 lb. RVP) | | 86.7 | | 89.8 |
| Excess $C_4$ | | 1.3 | | 0.8 |

| Inspections | Fresh charge | Debut. prod. | Stab. prod.* | Debut. prod. |
|---|---|---|---|---|
| Gravity, deg API | 58.8 | 54.0 | | 53.2 |
| ASTM dist.—IBP F. | 230 | 127 | | 131 |
| 10 | 248 | 179 | | 183 |
| 50 | 278 | 251 | | 264 |
| 90 | 351 | 326 | | 345 |
| E.P. | 394 | 412 | | 432 |
| Sulfur | 0.003 | Nil | | Nil |
| RVP | | 2.7 | 10 | 3.0 |
| Octanes: | | | | |
| F-1 clear | 24.6 | 82.3 | 83.1 | 80.1 |
| + 3cc TEL | 55.4 | 93.3 | 94.8 | 93.0 |
| Chem. composition Volume per cent | | | | |
| Paraffins | 77 | 57 | | 57 |
| Olefins | 0 | 2 | | 2 |
| Naphthenes | 17 | 0 | | 0 |
| Aromatics | 6 | 41 | | 41 |

* Tests on product after adding $C_4$ for 10 lb RVP.

**TABLE 1. Houdriforming operations for motor gasoline production.**

| Charge stock | Low paraffin content naphtha from mixed naphthenic crudes | Intermediate paraffin content naphtha from East Texas crude | High paraffin content naphtha from Kuwait crude |
|---|---|---|---|
| Gravity, deg API | 45.8 | 55.3 | 52.9 |
| ASTM distillation, deg F | | | |
| IBP | 255 | 188 | 244 |
| 10 | 285 | 215 | 289 |
| 30 | 300 | 232 | 306 |
| 50 | 316 | 252 | 320 |
| 70 | 334 | 280 | 338 |
| 90 | 361 | 317 | 366 |
| EP | 401 | 368 | 398 |
| F-1 clear octane | 61.3 | 55.6 | 23.5 |
| F-1 + 3cc TEL | 79.0 | 76.3 | 46.1 |
| RVP | 0.6 | 0.7 | 0.6 |
| Sulfur, wt % | 0.012 | 0.006 | 0.10 |
| Composition, vol % | | | |
| Paraffins | 31 | 44 | 64 |
| Olefins | 0 | 0 | 1 |
| Naphthenes | 46 | 42 | 20 |
| Aromatics | 23 | 14 | 15 |

| Houdriforming data | Mild operation | Severe operation | Mild operation | Severe operation | Mild operation | Severe operation |
|---|---|---|---|---|---|---|
| Yields, based on charge: | | | | | | |
| Debutanized reformate, vol % | 88.3 | 80.6 | 91.0 | 83.5 | 87.4 | 80.4 |
| Butanes, vol % | 3.9 | 7.0 | 2.7 | 6.2 | 6.1 | 9.3 |
| Propane, wt. % | 2.0 | 5.0 | 1.2 | 3.8 | 2.8 | 4.7 |
| Ethane, wt. % | 1.0 | 2.9 | 0.8 | 2.4 | 1.5 | 2.8 |
| Methane, wt. % | 0.6 | 1.8 | 0.5 | 1.0 | 1.1 | 2.2 |
| Hydrogen, wt. % | 2.0 | 1.8 | 1.6 | 1.3 | 0.7 | 0.7 |
| Debut. reformate F-1 clear octane | 92.0 | 101.0* | 80.0 | 92.0 | 76.8 | 90.0 |
| F-1 + 3cc TEL | 99.2 | 104.2* | 92.5 | 98.6 | 91.0 | 98.8 |
| Gravity, deg API | 39.7 | 36.5 | 52.7 | 45.8 | 50.7 | 47.7 |
| ASTM distillation, deg F | | | | | | |
| IBP | 170 | 148 | 173 | 149 | 141 | 130 |
| 10 | 248 | 230 | 212 | 196 | 216 | 195 |
| 30 | 282 | 280 | 234 | 222 | 250 | 250 |
| 50 | 306 | 306 | 260 | 248 | 284 | 283 |
| 70 | 322 | 320 | 284 | 281 | 308 | 299 |
| 90 | 378 | 375 | 323 | 325 | 340 | 349 |
| EP | 460 | 465 | 379 | 392 | 413 | 426 |
| RVP, psi | 1.0 | 1.9 | 1.9 | 3.0 | 2.1 | 3.6 |
| Sulfur, wt % | 0.002 | 0.002 | <0.001 | 0.002 | <0.001 | <0.001 |

* Octanes above 100 are extrapolated by method of Deters, J. F., Pet. Ref. Vol. 30, No. 6 (June, 1951)

### Process Description

Houdriforming is a fixed bed process utilizing two or more reactors in series, with interstage reheaters as illustrated by the simplified flow diagram, Fig. 1. Fresh naphtha charge is joined by a hydrogen-rich recycle gas stream and is then brought to the desired reaction temperature by heat exchange with the final reactor effluent and by heating in the fired preheater. The charge then enters reactor number one where it is partially converted. Since the major reaction is endothermic, the hydrocarbon stream sustains a drop in temperature during conversion, thereby necessitating reheating before each succeeding reactor. Thus, as shown in the flow diagram, the effluent from reactor number one passes through a

**TABLE 3. Houdriforming a $C_6$-$C_7$ fraction for benzene and toluene production.**

| | |
|---|---|
| Debutanized liquid—vol. % charge | 89.3 |
| $C_4$'s—vol. % charge | 2.6 |
| Propane—wt. % charge | 1.1 |
| Ethane—wt. % charge | 0.3 |
| Methane— wt % charge | 0.2 |
| Hydrogen—wt. % charge | 2.7 |

| Analysis: vol. % | Charge | Debutanized liquid |
|---|---|---|
| Benzene | 1.4 | 15.6 |
| Toluene | 4.6 | 31.7 |
| Methycyclopentane | 4.6 | 2.8 |
| Cyclohexane | 13.9 | 0.8 |
| Dimethylcyclopentanes | 9.6 | 3.0 |
| Methylcyclohexane | 23.1 | 0.3 |
| Olefins | — | 0.9 |
| Paraffins | 42.8 | 44.9 |

**TABLE 4. Houdriforming $C_8$ fraction for aromatics production.**

| | |
|---|---|
| $C_8$ + liquid, vol. % charge | 91.1 |
| $C_4$'s vol. % charge | 1.8 |
| Propane, wt. % charge | 0.9 |
| Ethane, wt. % charge | 0.4 |
| Methane, wt. % charge | 0.2 |
| Hydrogen, wt. % charge | 2.1 |

| Analysis: vol. % | Charge | $C_8$+ Liquid |
|---|---|---|
| Toluene | — | 5.4 |
| $C_8$ aromatics | 1.9 | 30.3 |
| $C_9$ aromatics | 1.1 | 5.1 |
| Naphthenes | 42 | 2.0 |
| Olefins | — | 2.0 |
| Paraffins | 55 | 52.2 |
| F-4 + 4.6cc TEL aviation blending P.N. (aromatic portion) | — 190 | |

reheat coil before entering reactor number two. Passage through a second reheat coil and the number three reactor completes the hydrocarbon conversion.

Effluent from the last reactor is cooled by heat exchange with fresh charge in series with final water cooler, and is then collected in the high pressure flash drum. A portion of the hydrogen-rich gas from this drum is recompressed to run pressure and recycled wth the fresh feed. Excess gas is delivered to the fuel gas system or to other process units for hydrogen utilization. Liquid from the high pressure flash drum flows to a stabilizing tower from which stabilized reformate is withdrawn. Stabilizer gas is delivered to the fuel gas system.

In the case of motor gasoline operation, the stabilized reformate is a finished product suitable for blending directly into final refinery gasolines. When producing aromatics, stabilized reformate is transferred to other processing facilities for extraction and purification.

The major process variables in Houdriforming are temperature, space velocity, pressure, and hydrogen to oil recycle ratio. By proper control of these variables, it is possible to vary the reforming severity widely as may be required in either motor gasoline or aromatics operation. Typical operating conditions are generally within the following limits:

| | |
|---|---|
| Temperature | 875-950 F. |
| Pressure | 250-600 psig |
| Space velocity | 1.5-5.0 v/hr/v |
| Hydrogen—oil mole ratio | 4-10 |

* * *

# Fluid Hydroforming

*Adaptation of the fluid catalyst principle to fixed-bed Hydroforming has yielded a much more efficient process of that reforming pioneer*

**J. C. RICHARDS* and M. TARNPOLL***

HYDROFORMING was the first catalytic naphtha upgrading process to become a commercial reality. This marked a distinct departure from the previous thermal reforming methods which employed a combination of heat and pressure to effect the desired reaction. In addition to increasing the octane number potential by reforming naphtha, the Hydroforming process proved to be a primary source for producing aromatics, such as benzene, toluene and xylenes, from naphtha fractions. The commercial feasibility of Hydroforming was demonstrated prior to and during World War II by the construction and successful operation of many such plants for the manufacture of high octane automotive gasoline, aviation gasoline blending stock and nitration grade toluene. One of these plants produced more than half of the total toluene used in TNT by the U.S. Armed Forces.

Since the introduction of the first fixed-bed Hydroformer in 1940, extensive pilot plant, catalyst and process development studies have been in progress. Coincident with this work has been the commercial extension of fluidized catalyst techniques, which have been applied very successfully at low pressure levels in catalytic cracking and various chemical processes. These research and commercial efforts have now culminated in the Fluid Catalyst Hydroforming process for the reforming of naphtha or the production of aromatics. The first commercial Fluid Hydroformer, of 2000 bbl per day, capacity, is in operation and at least eight other units representing a total capacity of 120,000 bbl per day are in various stages of design or construction. The largest of these units has a design capacity of 30,000 bbl per day.

The important process characteristics inherent in a fluid system include:

1. **An efficient method for contacting catalyst and hydrocarbons to provide an isothermal reaction;**
2. **A medium for providing effective heat transfer between flowing vapors and catalyst;**
3. **Facility for maintaining continuous and steady-state operation.**

These factors are reflected in simplified unit designs, improved quality of product, and low operating costs. The fluid process makes possible a continuous regenerative system, with both reaction and regeneration under isothermal conditions. Succesful operation under conditions of high carbon yield, regardless of whether this carbon is produced by high severity reforming or because of poor quality feedstock, provides a significant index as to the inherent flexibility of the process. The continuous replacement of catalyst results in a stable operation with catalyst at a uniform equilibrium activity.

In general, the Fluid Hydroforming process offers the following advantages:

1. *Continuous regenerative process. Continuous regeneration provides considerable flexibility with regard to naphtha feed stock composition or boiling range, and variation in operating contions.*
2. *Long operating stream time due to the ability to control any decline in catalyst activity by periodic or continuous additions of fresh catalyst.*
3. *High octane potential. Debutanized gasoline can be produced having a Research octane number of 95 and higher without the use of tetraethyl lead.*
4. *Essentially constant temperature operation and elimination of "channeling," results in maximum utilization of catalyst with concomitant improvement in yields and product quality.*

The catalyst presently used in Fluid Hydroforming is a molybdena type, which is relatively inexpensive. The properties of the catalyst render it insensitive to sulfur and metallic con-

*The M. W. Kellogg Company.

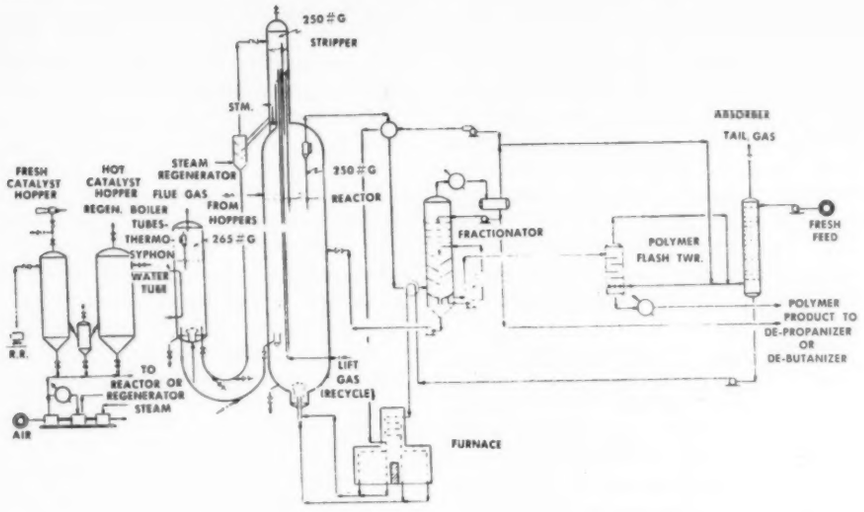



**FIG. 1. Side-by-side Fluid Hydroforming unit.**

taminants that often destroy the activity of other catalysts. The catalyst is also characterized by long life and insensitivity to operating upsets and feed stock variations, thus making it applicable to the processing of sulfurous or otherwise poor quality naphtha.

An important consideration in design of the fluid system, is the efficiency of catalyst recovery. This may be accomplished by the use of filters or cyclones and, in either case, the loss of catalyst can be confined to an amount considerably less than 0.1 lb per bbl of naphtha feed, which is an important economic factor in the operation.

Two types of Fluid Hydroformers have been designed by The M. W. Kellogg Company. The first, designated the "Side-by-Side" Fluid Hydroformer, is illustrated in the flow diagram of Fig. 1. The second unit, known as the Orthoformer*, is represented by the flow diagram in Fig. 2.

## Side-by-Side Fluid Hydroforming

With the reactor and regenerator situated side-by-side, as illustrated in Fig. 1, spent catalyst is withdrawn continuously from the lower part of the reactor bed into an internal vertical riser, and lifted by hot recycle gas to the spent catalyst hopper and stripper above the reaction chamber. Excess catalyst and riser gas return to the reactor through overflow and vent pipes.

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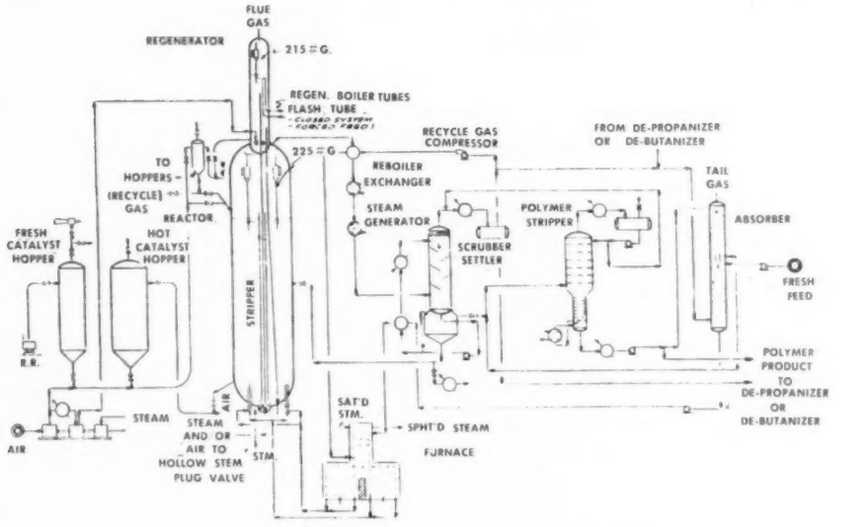


**FIG. 2. Orthoforming Fluid Hydroforming unit.**

The spent catalyst is stripped of hydrocarbons with steam before passing downward into the spent catalyst standpipe, and is then conveyed by aeration gases around the transfer line through a slide valve and into the bottom of the regenerator. The regenerated catalyst is continuously returned through an external transfer line to the reactor bottom. Catalyst flow rate is regulated by a slide valve which responds to changes in the regenerator bed level.

Both the regenerator and reactor are located near grade. The pressure in the reactor is controlled at about 10-15 psig higher than the reactor. Coke deposited on the catalyst as a product of the hydroforming reaction is burned off in the regenerator, combustion air entering through an internal distributing grid. Excess heat generated by coke combustion and partial oxidation of the catalyst is utilized to produce steam in parallel vertical boiler tubes placed within the regenerator and largely immersed in the catalyst bed. The tubes are connected to top and bottom headers oustide of the vessel, feed water being supplied to the lower header by gravity flow from an elevated steam drum. The steam produced flows from the upper header to the steam drum and to the refinery steam main. Regenerator catalyst temperatures are maintained at about 1100 F. by raising or lowering the bed level.

An alternative to the thermo-syphon boiler system, is the operation of the regenerator boiler system as a flash tube, forced circulation boiler with control based on the amount of water fed to the tubes. This system permits the regenerator catalyst bed to be held constant.

Fresh naphtha feed is used in an absorber to recover light ends from the process gases leaving the system, and also serves to strip dissolved oxygen from the naphtha, thereby reducing gum formation in the naphtha furnace. The rich naphtha from the absorber bottom, constituting the furnace charge, is pumped through heat exchange to the furnace, where it is vaporized, and then to the reactor bottom. Here, in combination with hot recycle gas, it contacts the fluidized catalyst.

The reactor effluent contains sufficient heat to preheat the recycle gas, and provide preheat for the naphtha furnace charge. The cooled reactor effluent is then directed into a fractionator tower where the products of reaction are separated and the entrained catalyst is scrubbed out by a slurry reflux stream. The settled, dense slurry is then pumped directly to the reactor to recover the catalyst. Decanted oil which is the supernatant

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liquid from the settling of the slurry, flows under pressure from the top of the settling section to the polymer flash tower.

The recycle gas and products of reaction pass out of the top of the fractionator tower, through a condenser and are separated in the reflux drum. Recycle gas is compressed and returned through heat exchange and then to the furnace, where it is heated to the desired temperature, before re-entering the reactor. Liquid product flows to a depropanizer and/or debutanizer to produce the desired finished gasoline and propane or butane fractions.

The polymer product from the operation is extremely high in aromatic content. It has a high octane number and can be included in the refinery motor gasoline pool.

### Orthoforming*

Orthoforming is a logical development in the mechanical design of Fluid Hydroforming, combining the reactor and regenerator into a single vessel and simplifying the movement of catalyst between the two vessels, as shown in the diagram of Fig. 2. This basic concept of the Orthoforming operation originated with Orthoflow Fluid catalytic cracking where, over the past several years, it has been successfully applied to a number of commercial units.

The general process design is the same for both types of Fluid Hydroformers; however, there are certain points of difference in detailed design of the Orthoformer as follows:

1. The reactor, stripper, and regenerator are combined in a single vessel with a common internal head separating the regenerator from the reactor.
2. External catalyst transfer lines have been eliminated, permitting the use of straight internally located lines which allow dependable, straight line catalyst flow. The absence of turbulence at changes in direction, the omission of blasting and aeration connections, and the stream-lined catalyst pickup and mixing details which are thus made possible minimize transfer line erosion. Equally important is the fact that the high pressure, high hydrogen content catalyst — gas flow is entirely contained within the vessels.
3. Catalyst flow is from a point near the top of the reactor catalyst bed into the stripper, up through the spent catalyst riser into the regenerator, and then down the regenerated catalyst standpipe to the bottom of the reactor bed. Flow of spent catalyst in the riser is controlled by a hollow-stem plug valve and catalyst flow out of the regenerated catalyst standpipe is controlled by a solid-stem plug valve.
4. The spent catalyst stripper is situated within the reactor, which allows a higher ratio length to diameter stripper thereby providing improved stripping efficiency. In addition, this location allows virtually reaction temperature stripping thus improving removal of entrained, absorbed hydrocarbons and chemi-sorbed hydrogen from spent catalyst before regeneration.
4. Increased heat efficiency is realized, since the catalyst carrier lines are immersed in the hot catalyst bed. Heat loss is therefore confined to that from the vessels proper.

The first commercial 2000 bbl per day Fluid Hydroformer went on stream over one year ago. Preliminary evaluations of the process results from this operation indicate the yield — octane relationship to be at least as good as predictions based on test unit and pilot plant data. The unit has successfully demonstrated operability, extreme flexibility in throughput (1100-2600 bbl per day), insensitivity to variations in operating conditions, and the ability to handle naphthas of widely varying boiling range. No reduction in catalyst activity or unusual catalyst attrition has been observed in the operations to date. Catalyst losses during an extended run have been less than 0.1 pound per barrel of naphtha feed, which is considered well within the economic limit. * * *

# HYPERFORMING

*Uses continuous regeneration of cobalt-molybdate catalyst, 400 psig, and 800-900 F operating conditions*

CLYDE BERG*

THE Hyperforming process is a general purpose reforming and refining operation that utilizes a moving bed of catalyst with continuous regeneration. This process carries out the reforming of straight-run naphthas, as well as blends of straight-run and cracked stocks, to effect major uplifts of octane value with high overall liquid yields. Almost complete desulfurization is effected simultaneously. In handling straight-run stocks substantial quantities of hydrogen are produced.

The reforming and desulfurization reactions are carried out in the presence of a cobalt-molybdate catalyst and a hydrogen-rich recycle gas stream. Reactor operating pressure is near 400 psig; reactor temperatures are in the range of 800-900 F.

### Basic Operation

In Fig. 1 is given a diagram of the Hyperforming process. It will be noted that the catalyst moves downward through the reactor under gravity flow and is returned back to the top of the reactor by means of mass conveyance in a catalyst transfer line. Simultaneous with this vertical lift, regeneration is carried out. By use of continuous regeneration in the course of catalyst movement, a substantial economy in plant construction is effected and plant maintenance is reduced over that of cyclic processes.

In reviewing the internals of the Hyperforming unit, it will be noted that the feed is introduced near the bottom of the reactor and moves upward countercurrent to the catalyst. Hot hydrogen recycle gas is introduced below the naphtha feed and at several interheating points. The naphtha and recycle gas leave the top of the reactor.

Regeneration of the catalyst is carried out in the Hyperflow lift line employing a recycle of flue gas with an oxygen content below two per cent. This combination of a moving bed together with controlled oxygen content in the flue gas limits the peak temperature rise and provides precise control with the assurance of moderate temperatures in the removal of coke from the catalyst.

Circulation of catalyst in the Hyperforming unit is quite low. Less than five tons per hour of catalyst will be circulated in a typical Hyperforming

*Manager, development department, Union Oil of California.

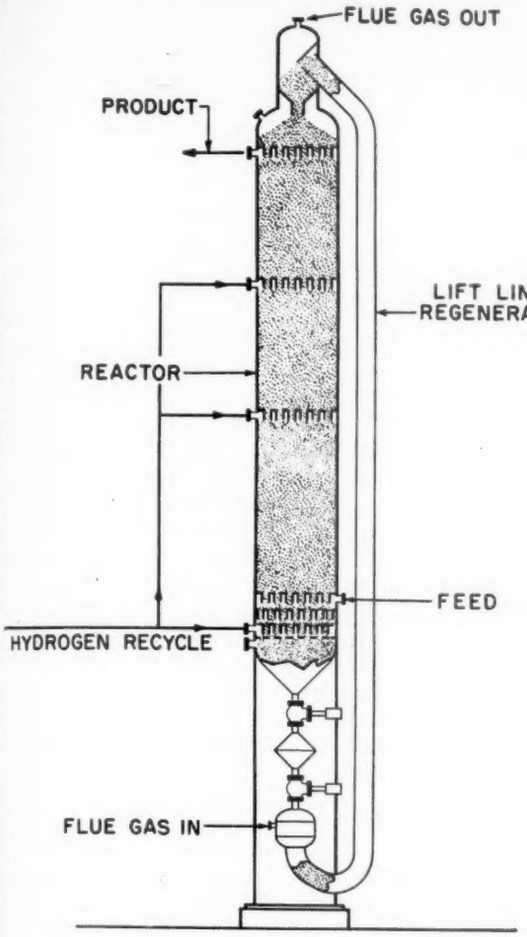



FIG. 1. Cross-section of Hyperforming unit showing arrangement of steps and sequence of operating procedures.

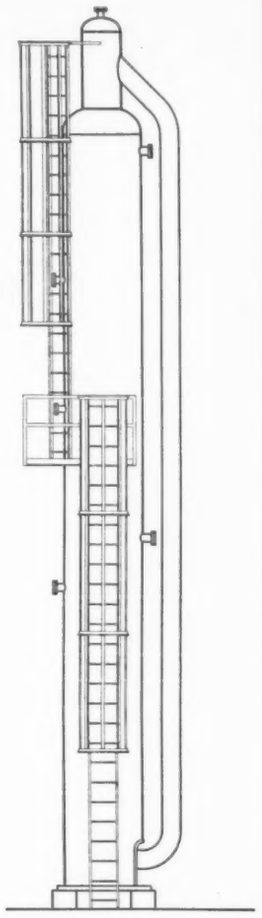


FIG. 3. Details of assembly of components of a Hyperforming unit.

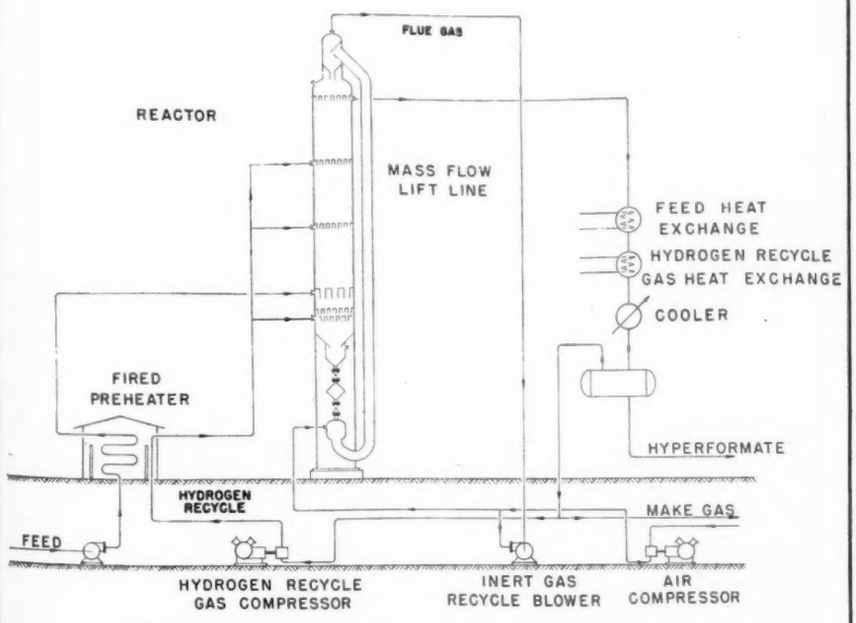



FIG. 2. Typical flowsheet of a commercial Hyperforming unit.

plant processing 10,000 bbl daily of straight-run. This low catalyst circulation combined with low attrition effects provided by the use of the Hyperflow conveying principle, leads to minimum overall costs in catalyst makeup.

### Catalyst

To meet the requirements of general purpose reforming and upgrading operations, it is necessary that the process be capable of processing the full range of naphtha stocks which a refiner may find desirable to reform. In this regard it is highly important that an occasional contamination of stocks does not cause serious complications in plant operation. The ability to refine both straight-run and high sulfur naphtha of all varieties from inferior crudes without deleterious effects or catalyst poison is well established insofar as the cobalt-molybdate catalyst is concerned.

### Commercial Design

Fig. 2 presents a diagramatic flow sheet for a commercial Hyperforming plant and Fig. 3 assembly details of the reactor-regenerator system.

Typical of the process application to various stocks is the following:

1. A 250-385 F straight-run naphtha having 0.05 per cent sulfur, 0.01 per cent nitrogen, and an octane rating of 63 F-1 + 3cc TEL Hyperformed to give a $C_4+$ product having an octane rating of 95 F-1 + 3cc TEL.
2. A 270-385 F blend of cracked and straight-run naphthas having 0.58 per cent sulfur, 0.02 per cent nitrogen, and an octane rating of 73 F-1 + 3cc TEL was Hyperformed to give a $C_4+$ product containing less than 0.01 per cent sulfur and having an octane rating of 96 F-1 + 3cc TEL.

The ability of Hyperforming to process straight-run stocks and blends of straight-run and cracked stocks is a major advancement in refining technique and of particular interest to refiners who must process inferior crudes. The technique utilizes the hydrogen released in the dehydrogenation of naphthenes for the simultaneous elimination of sulfur, nitrogen, and oxygen in inferior stocks. Olefins are saturated as well. This efficient exchange of hydrogen between the straight-run gasoline and the inferior high sulfur and/or cracked naphtha, leads to refined product of excellent quality.

The Hyperforming process is licensed by the Union Oil Company of California through the Commercial Development Division of the Research and Process Department. * * *

# PLATFORMING

*A platinum-containing catalyst not requiring regeneration upgrades low-quality naphthas for either better motor fuels, or aromatics, or both*

J. G. ECKHOUSE*

UOP Platforming is a fixed bed catalytic reforming process employing a specific platinum-containing catalyst, operating at temperatures ranging from 850-960 F. and pressures ranging from 200 to 700 pounds per square inch, in the presence of hydrogen gas.

It was developed by the Universal Oil Products Company in response to the industry wide need for an economic method of upgrading low octane gasoline components to premium quality motor fuels, and for producing aromatics and high-quality aviation gasoline components from selected naphtha cuts.

### Charge

The process is capable of handling virtually any type of feed stock boiling in the gasoline range. Straight run naphthas and gasolines, thermally cracked gasolines, coker gasolines, visbreaker gasolines, natural gasolines, etc. are examples of stocks which have been successfully processed, both commercially and in pilot plants for premium motor fuel production. These stocks may be derived from both sweet and sour crudes, and may be either very low octane or higher.

For aromatics or avgas operations, selected naphtha fractions are processed.

*Universal Oil Products Company.

### Products

In motor fuel operation, typical products range from 93 to 100 F-1 octane number with 3 cc of TEL as may be desired to meet market requirements. Typical products are stable and sweet and require no rerunning or further processing.

High purity benzene, toluene, xylenes and other aromatics can be made either as separate compounds or in admixture depending on the naphtha cut selected as charge. For the production of such aromatics it is generally desirable to follow the Platforming unit with an aromatics extraction unit such as the UDEX process followed by distillation to recover the pure components.

Either avgas base stock suitable for grade 100/130 avgas blending, or aromatic concentrates suitable for grade 115/145 avgas blending may be produced by selected operation.

High purity hydrogen gas is also produced which may be utilized as an inexpensive source of hydrogen for hydrogenation processes such as Unifining.

### Description of Process

The accompanying flow diagram depicts a typical Platforming unit. The unit may generally be divided into three sections; the reactor-heater section in which the charge plus recycle gas is heated and passed over the catalyst where the reaction takes place; the separation and compression section in which the reactor effluent is separated into gas and liquid streams, the gas being compressed for recycling; and the stabilization section in which the separator liquid is stabilized to the desired vapor pressure.

Depending on the character of the feed stock, it may be desirable to add a fourth section for pretreatment of the feed to remove undesirable components contained therein, or a recycle gas scrubbing system to remove $H_2S$ from this gas.

Flow through the unit is straightforward. Incoming feed is mixed with recycle gas, preheated by heat exchange

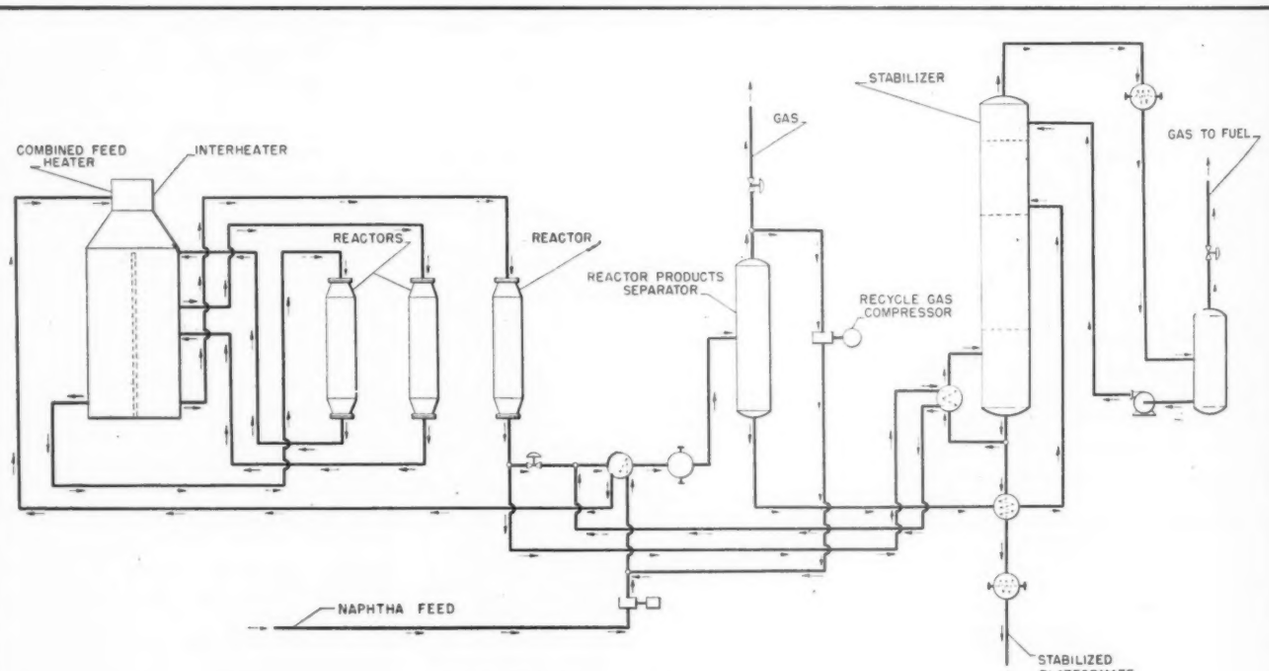



**FIG. 1. Flow diagram of a Platforming unit.**

with reactor effluent, heated to reaction temperature in the charge heater and charged to the first reactor. The predominant reaction of dehydrogenation is endothermic and this heat of reaction is replaced in the reheat coils between the reactors in order to maintain optimum reforming temperatures in all three reactors.

The products from the last reactor after heat exchange with the cold charge, and use as reboiler heat medium on the stabilizer, or in some cases on other fractionating columns, are cooled, and separated in the reactor products separator. The gas required as recycle is compressed and returned to the feed stream. The net gas make may go either to fuel gas, an absorption system, or to a hydrogenation unit as raw material.

The liquid from the separator may be either depropanized, debutanized, or dependentanized in the stabilizer depending on plant volatility requirements. The overhead gas from the stabilizer may go either to refinery fuel or to a gas recovery unit. Stabilized Platformate from the bottom of the stabilizer flows to finished gasoline storage without further treatment.

The principal chemical reactions involved are dehydrogenation of naphthenes to aromatics, hydrocracking of high molecular weight paraffins to lower molecular weight paraffins, isomerization of paraffins and naphthenes, dehydrocyclization of paraffins, and hydrogenation of sulfur compounds to hydrogen sulfide.

### Operating Conditions

The four major process variables are temperature, space velocity, pressure and hydrogen recycle rate. As previously stated, operating temperatures range from 850 degrees to 960 degrees F and pressure range from 200 to 700 psi. Space velocities, and hydrogen recycle ratios are determined for each installation to produce optimum results.

Choice of operating conditions depends on the desired results from a given charge stock. In the Platforming process, there is an equilibrium established between the hydrogen recycle and the carbon deposit on the catalyst in the reactors. Carbon is thus continuously being laid down on the catalyst and removed by the hydrogen recycle. In view of the long catalyst lives without excessive carbonization which have been obtained in commercial operations, it has not been found necessary to install outside or additional facilities for regenerating the catalyst.

All catalytic processes require treatment of certain feed stocks to remove poisons, which, if present in the feed, would attack the catalyst. Our experience shows that catalytic reforming is no exception. One of the worst such offenders in commercial operations is arsenic. Platinum has a great affinity for arsenic and provisions must be made if it is present in the feed in objectionable amounts to reduce it to an acceptable level before charging to the Platforming catalyst. It is significant to point out that platinum has such a great affinity for arsenic that it is found in nature as the arsenide and mined as such. We know now the effects of trace amounts of contaminants such as arsenic, sulfur, and others which may be present in the feed stock, and have developed methods for protecting the catalyst where protection is required. Of the 36 Platformers which are now in operation, 8 employ some type of feed pretreatment to obtain best catalyst life. The other 28 units now in operation have no special feed pretreatment for contaminants for the simple reason that excessive contaminants are not present in these stocks. A careful analysis of the stock must be made to determine this, and commercial experience with contaminated stocks is the best way of finding out what precautions to take.

The best record of catalyst life to date has been made by the unit operated by the Johnson Oil Refining Company in Cleveland, Oklahoma. This unit operated for 2 years and 5 months on its initial charge of catalyst and reached a catalyst life of 203 bbl per pound of catalyst. Many other units have reached lives of over 100 bbl per lb. The average of all runs on all operating units exceeds 65 bbl per lb. This average includes those runs on the first units when we knew much less about catalyst contaminants than we now do.

### Yields

Typical yields when operating on a Mid-Continent naphtha at several different operating conditions are shown below:

| | Charge stock | Platformates | | |
|---|---|---|---|---|
| Octane ratings | | | | |
| F-1 clear | 32.4 | 85 | 90 | 95 |
| F-1 + 3cc TEL/gal. | 56.4 | 96 | 98 | iso+ 0.06 |
| Yields | | | | |
| $C_3$ and lighter wt. % | — | 4.0 | 5.3 | 7.4 |
| $C_4$ volume % | — | 4.1 | 5.6 | 7.7 |
| $C_5$ + gasoline vol. % | — | 88.3 | 85.5 | 81.2 |
| 10 lb RVP gasoline vol. % | — | 100.4 | 97.0 | 91.9 |
| Debutanized gasoline product | | | | |
| RVP | — | 2.3 | 2.6 | 3.0 |
| API | 52.6 | 46.6 | 45.8 | 44.7 |
| IBP | 230 | 144 | 140 | 132 |
| 10% | 255 | 200 | 191 | 173 |
| 30% | | | | |
| 50% | 308 | 285 | 281 | 272 |
| 70% | | | | |
| 90% | 372 | 366 | 366 | 365 |
| EP | 397 | 410 | 412 | 413 |

### Estimated Operating and Investment Costs

Operating costs will vary with the size of the unit and the plant location. However, for a typical case, utilities would cost in the neighborhood of 4 to 5 cents per barrel of feed for a 1,000 bbl unit. With catalyst cost estimated at 4 cents per barrel, operating labor at 4 to 5 cents a barrel, royalty at 6 cents a barrel, taxes, insurance, and maintenance at another 7 to 10 cents a barrel, a total operating cost would be 25 to 30 cents per barrel of feed. Initial investment costs, of course, vary widely depending upon the type of design and construction, but are normally from 150 to 300 dollars erected cost per daily barrel of feed capacity.

### Commercial Installations

Approximately 80 units have been licensed of which 36 are now running. The first unit to go on stream is now in its fifth year of successful operation converting low octane Michigan naphthas to premium motor fuel.

These units range in size from 600 B/SD to 29,000 B/SD reactor charge capacity, have been designed for a wide variety of charging stocks including virtually every type of naphtha and to make products ranging from premium motor fuel to high purity benzene, toluene, and xylenes, and avgas blending components. Units are located throughout the world including Japan, Australia, Arabia, England, Scotland, France, Germany, Canary Islands, Lebanon, Belgium and Canada, as well as the U. S. A.

### Advantages of Platforming

The Platforming process has many proved advantages over competitive processes. As the process which pioneered the use of platinum as a catalyst for reforming, it brings to the refiner a wealth of commercial experience and proven commercial performance unapproached by any other process.

Platforming time and again has proved that it holds an economic advantage over other catalytic reforming processes because Platforming gives higher yields, maintains these higher yields throughout the catalyst life, and has lower catalyst costs resulting from longer catalyst lives. Further, it provides higher potential octanes due to the lower carbon forming tendencies of the catalyst and its ability to selectively promote the desired reactions. Operating and investment costs are minimized by not requiring regeneration to obtain long catalyst life. * *

☆ ☆ ☆

"Last night I met a cutie that I used to date ten years ago!"

"Has she kept her girlish figure?"

"Kept it? Man, she doubled it!"

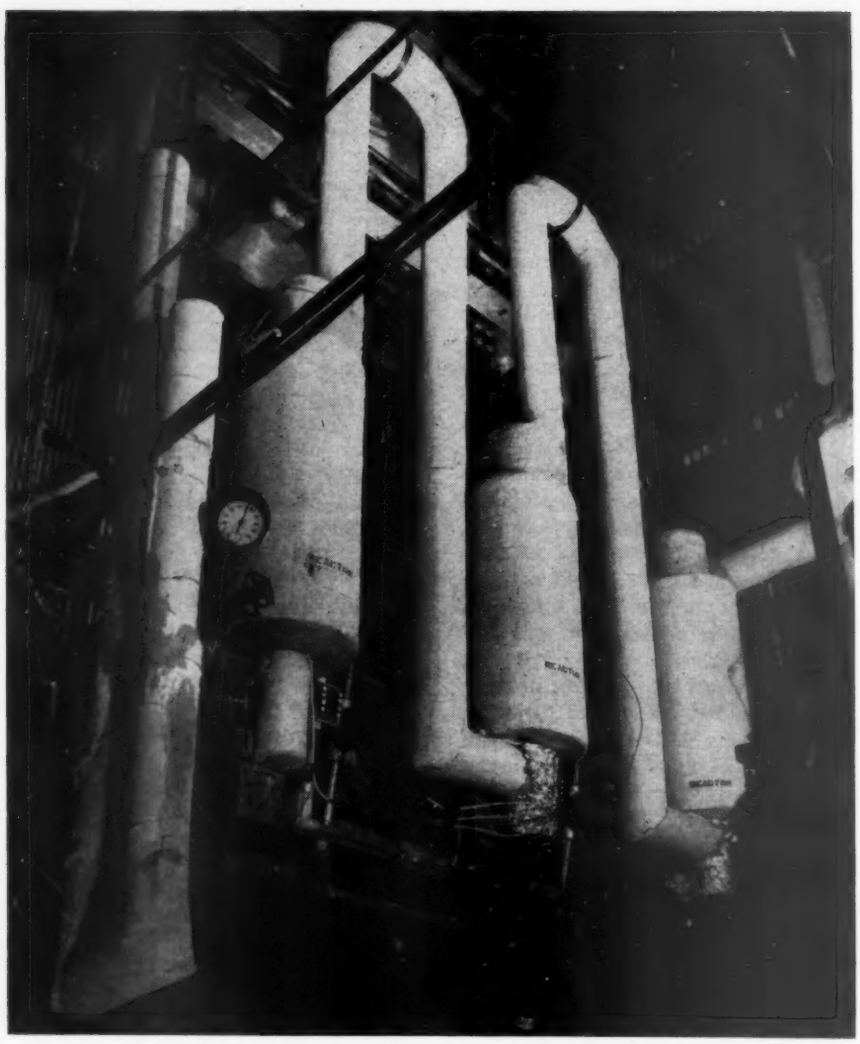


**FIG. 1. Three reactors, the heart of the process in the pilot plant at Sinclair Research; these reactors are charged with catalyst in fixed beds.**

# Sinclair-Baker Reforming

*New regenerative RD-150 catalyst offers long life, and wide choice of operating conditions*

**W. H. DECKER***

THE recent trend in higher compression ratios for automotive engines has resulted in a steady increase in the octane requirements for motor gasolines. These higher motor gasoline octane levels together with the increasing markets for aromatic chemicals have made it desirable to improve existing reforming processes. Accordingly the Sinclair Research Laboratories, Inc., and Baker & Co., have developed a new platinum catalyst to be used as the basis for an improved reforming process. This process was announced at the May 11-14, 1953 meeting of the Division of Refining of the API. The M. W. Kellogg Company is offering this catalyst for fixed-bed units with or without regeneration.

The new catalyst, RD-150, embodies a number of specific advantages, among them being:

a. **Selective isomerization and dehydrogenation of naphthenes.**
b. **High paraffin cyclization activity.**
c. **High hydrogen production with reduced hydrocracking activity.**
d. **Regeneration characteristics so that high activities may be maintained during the life of the catalyst.**
e. **Resistance to permanent poisoning effects with normal concentrations of sulfur, metals, or water in the virgin naphthas.**

The combination of these properties produces a superior catalyst that will maximize reformate yield-octanes for all reforming operations and for all naphtha charge stocks. The ability to regenerate guarantees long catalyst life, in terms of barrels of reformate per pound of catalyst, and provides insurance against loss in activity due to operational upsets.

The regenerative nature of RD-150 catalyst permits considerable variation in the selection of the operating conditions. Thus the unit can be "tailor-made" for the processing of any naphtha charge stock. In this regard, there are two general types of operations that have been developed. These are (1) the high pressure continuous process and (2) the low pressure regenerative process, each of which has certain advantages. The high pressure continuous process is particularly suited to the treatment of highly naphthenic stocks at high space velocities with moderately severe operations. Under these conditions, the catalyst activity decline rate is slow and only infrequent regenerations are required to maintain activities near the virgin level. In contrast, the low pressure regenerative process is more suited to high severity operations with paraffinic charge stocks, which require higher temperatures, and lower space velocities. This is because of its superior yield-octane characteristics, when compared with the high pressure continuous process.

## Processing Description

One method of continuous processing is shown on flow sheet, Fig. 2. The three reactors employed are of the fixed bed, down flow, adiabatic type designed to minimize adverse thermal effects. The virgin naphtha charge is combined with the hydrogen-rich recycle gas stream, exchanged against reactor effluent, and fed into the preheating furnace. The preheated vapors then pass in series through the three (or more) reactors and the two (or more) interheaters. Interheating between reactors is required to maintain reactor temperatures as the reforming reactions are primarily endothermic. During operations, the reactor temperatures are slowly increased, throughout the processing cycle, to compensate for the gradual loss in catalyst activity.

The reactor effluent is exchanged

*Sinclair Research Laboratories, Inc.

against the fresh feed, cooled to atmospheric temperature, and passed into a high pressure flash drum. Here the reactor product is split into two streams. The liquid product flows to a column where the reformate is stablilized to the desired vapor pressure. Rerunning of the stabilized reformate is not required since no heavy polymer is produced by the catalyst. The light gases from the stabilizer are released to fuel or to subsequent processing facilities. The hydrogen-rich gas from the flash drum is compressed and recycled to the inlet naphtha system. The net gas make is released from the recycle gas stream to fuel or to processing equipment utilizing this hydrogen-rich gas. An absorber can be incorporated in this gas release system under conditions or price structure for which the recovery of the heavier fractions from the gas would be profitable.

Commercial installations of this process involve only conventional equipment so that the first cost is kept at a minimum. The use of alloy steels is limited to equipment in high temperature hydrogen service with the exception of the reactors. Reactors may lined internally with insulating refractory so that the vessels can be fabricated from low carbon steels. This would represent an appreciable reduction in the initial investment because of the high cost of alloy vessels for this service.

At normal virgin naphtha concentrations, the RD-150 catalyst is resistant to poisoning from sulfur, water, or metals such as arsenic and therefore treatment for removal of these materials is not usually required. It may be desirable, however, to include treating equipment when processing high sulfur naphthas. The removal of sulphur may be accomplished either by treatment of the feed or of the recycle gas, whichever is more economical.

### Catalyst Regeneration

Equipment required for regeneration is shown with dotted lines on the flow sheet. Regeneration of the catalyst becomes desirable when the accumulation of carbonaceous material has reduced the activity and selectivity of the catalyst below acceptable limits. Combustion of these carbon deposits in a low pressure dilute air stream will substantially restore the activity to its initial value. The time required for this operation is primarily dependent upon the severity of the processing and the quality of the naphtha, both of which will determine the amount of carbon present on the catalyst. The actual regeneration is accomplished by stopping the naphtha flow, purging and pressuring with inert gas and then admitting air until the burning is complete. The unit is returned to naphtha processing after purging the inert gas from the system.

The equipment required for regeneration involves only an air compressor and an inert gas generator. This regeneration equipment can be installed in several ways. For low or moderately severe processing operations which require infrequent regenerations the arrangement would be that described above. However, for high severity operations requiring frequent regenerations the reactor arrangement would be that the regeneration would be accomplished without interruption of the naphtha processing. This would be done by the regeneration of a single reactor at a time.

The selection of the type of process to be used is dependent upon an economic study of the factors involved. Such a study must make allowance for both present and future markets for higher octanes and aromatic chemicals. The continuous process will require a smaller initial capital investment than will the regenerative process. The regenerative process, however, has the advantage of improved yields, a greater flexibility in operations, and continuity of processing.

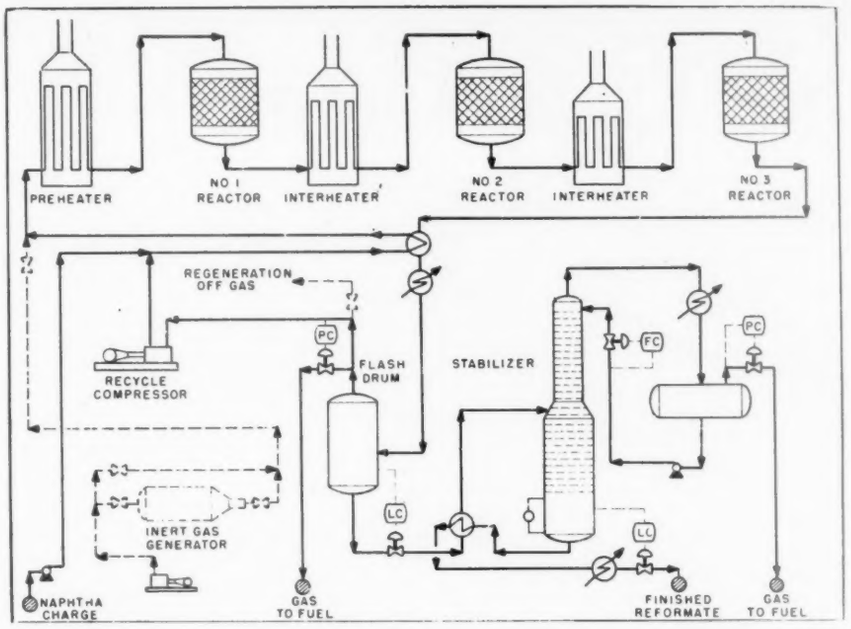



**FIG. 2. Diagrammatic illustration of the main steps in cat reforming, with the RD-150 regeneratable catalyst.**

**TABLE 1. Naphtha feed stock characteristics.**

| Crude Type | | Mid-Continent | Persian Gulf |
|---|---|---|---|
| Gravity | °API | 54.1 | 54.0 |
| I. B. P. | °F | 236 | 240 |
| 10% | °F | 257 | 283 |
| 50% | °F | 291 | 310 |
| 90% | °F | 341 | 337 |
| E. P. | °F | 373 | 355 |
| Analysis | | | |
| Naphthenes | Vol. % | 43.2 | 19.4 |
| Aromatics | Vol. % | 7.7 | 14.7 |
| Paraffins | Vol. % | 48.8 | 65.1 |
| Sulphur | Wt. % | 0.021 | 0.087 |
| Octanes, Research | | | |
| Clear | | 36.5 | 29.6 |
| + 3 ml TEL/Gal. | | 61.0 | 52.5 |

**TABLE 2. Yield data at 85 research octane.**

| Operation | 500 Psig Continuous | | 200 Psig Regenerative | |
|---|---|---|---|---|
| Crude Type | Mid-Continent | Persian Gulf | Mid-Continent | Persian Gulf |
| Yields | | | | |
| $H_2$ CF/Bbl. | 860 | 405 | 910 | 555 |
| $C_1$ Wt. % | 1.0 | 1.2 | 0.6 | 0.9 |
| $C_2$ Wt. % | 1.6 | 2.4 | 1.1 | 1.8 |
| $C_3$ Wt. % | 2.5 | 4.0 | 1.9 | 3.1 |
| $C_4$ Vol. % | 3.6 | 6.1 | 2.6 | 4.7 |
| $C_4$-EP Vol.% | 90.9 | 91.0 | 91.3 | 91.4 |
| $C_5$-EP Vol. % | 87.3 | 84.9 | 88.7 | 86.7 |
| 10# RVP Vol. % | 100.4 | 96.2 | 102.5 | 99.0 |
| Octanes, Research | | | | |
| $C_5$-EP Clear | 85.0 | 85.0 | 85.0 | 85.0 |
| $C_5$-EP +3 ml TEL/gal. | 94.6 | 95.5 | 94.6 | 95.5 |
| Reformate $C_5$-EP | | | | |
| Gravity °API | 48.0 | 48.9 | 44.8 | 50.9 |
| I. B. P. °F | 141 | — | 130 | — |
| 10% °F | 220 | — | 209 | 177 |
| 50% °F | 286 | — | 285 | 270 |
| 90% °F | 340 | — | 360 | 362 |
| E. P. °F | 414 | — | 448 | 419 |
| RVP PSIG | 2.4 | 3.4 | 2.0 | 2.9 |
| Sulfur Wt. % | Neg. | Neg. | Neg. | Neg. |

**TABLE 3. Yield data at 95 research octane.**

| Operation | 500 Psig Continuous | | 200 Psig Regenerative | |
|---|---|---|---|---|
| Crude Type | Mid-Continent | Persian Gulf | Mid-Continent | Persian Gulf |
| **Yields** | | | | |
| $H_2$ CF/Bbl. | 910 | 550 | 1115 | 760 |
| $C_1$ Wt. % | 1.8 | 2.0 | 1.2 | 1.5 |
| $C_2$ Wt. % | 2.8 | 3.8 | 2.0 | 2.9 |
| $C_3$ Wt. % | 4.2 | 6.2 | 3.0 | 4.9 |
| $C_4$ Vol. % | 6.2 | 9.7 | 4.4 | 7.4 |
| $C_5$-EP Vol. % | 87.0 | 85.6 | 87.8 | 87.1 |
| $C_5$-EP Vol. % | 80.8 | 75.9 | 83.4 | 79.7 |
| 10# RVP Vol. % | 91.7 | 84.5 | 95.6 | 89.7 |
| **Octanes, Research** | | | | |
| $C_5$-EP Clear | 95.0 | 95.0 | 95.0 | 95.0 |
| $C_5$-EP + 3 ml TEL/gal. | 100.1 | 100.2 | 100.1 | 100.2 |
| **Reformate $C_5$-EP** | | | | |
| Gravity °API | 46.7 | 45.5 | 42.3 | — |
| I. B. P. °F | 138 | — | 126 | — |
| 10% °F | 210 | — | 207 | — |
| 50% °F | 281 | — | 288 | — |
| 90% °F | 352 | — | 363 | — |
| E. P. °F | 420 | — | 457 | — |
| RVP PSIG | 3.3 | 4.5 | 2.6 | 3.8 |
| Sulfur Wt. % | Neg. | Neg. | Neg. | Neg. |

### Typical Yields

The selectivity and performance of the RD-150 catalyst is illustrated by a review of typical yield-octanes when processing a naphthenic and a paraffinic naphtha at several different conditions. The feed stock characteristics are shown in Table 1. A Mid-Continent and a Persian Gulf naphtha have been selected as these stocks are representative of the two extremes in virgin naphtha quality. The yields for 200 and 500 psig operation at 85 $C_5$-EP clear RON level are presented in Table 2, while those for the 95 $C_5$-EP clear RON level are presented in Table 3.

It is evident from a review of these data that, for the octane ranges considered, the 200 psig regenerative process will produce less propane and lighter, more hydrogen, and more $C_5$-EP reformate, than will the 500 psig continuous process. The $C_5$-EP reformate from the low pressure regenerative operations will have a lower RVP than that produced at higher pressures. When compared at the same reformate octane the regenerative process will accordingly produce significantly more 10-lb RVP gasoline. This yield advantage will also increase with increasing paraffinicity of the naphtha feed stock and with an increase in the octane of the reformate. The yields of $C_4$-EP reformate for both operations are approximately the same. Where additional butanes are not available, so that the production of $C_4$+ reformate is the primary consideration, there is little yield advantage for the low pressure regenerative operations.

### Aromatic Production

Market requirements for aromatic chemicals are gradually increasing, and it is therefore desirable to be able to efficiently produce these aromatics. It is possible to realize high aromatic yields when reforming with RD-150 catalyst due to excellent selectivity in naphthene and paraffin conversion, without excessive losses from hydrocracking. As an illustration of the performance of the catalyst for aromatic production, data are shown in Table 4 for the treatment of several fractions from a California naphtha. These data on aromatic production also illustrate the hydrogen producing ability of the RD-150. Utilization of this by-product hydrogen for petrochemical production, ammonia synthesis, hydrodesulfurization, etc., may also represent a valuable supplement to the economics of the main process.

**TABLE 4. Aromatic production from California naphthas.**

| Charge Stock Characteristics Fraction: | | $C_6$ | $C_7$ | $C_8$ |
|---|---|---|---|---|
| Gravity | °API | 55.7 | 59.1 | 55.4 |
| I. B. P. | °F | 161 | 192 | 245 |
| 10% | °F | 163 | 194 | 248 |
| 50% | °F | 165 | 198 | 251 |
| 90% | °F | 169 | 207 | 256 |
| E. P. | °F | 195 | 215 | 266 |
| Paraffins | Vol. % | 9.6 | 33.8 | 36.2 |
| Naphthenes | Vol. % | 87.8 | 62.5 | 59.0 |
| Aromatics | Vol. % | 2.6 | 3.7 | 4.8 |
| **Produc Yields** | | | | |
| Hydrogen | CF/Bbl. | 2110 | 2000 | 1350 |
| $C_1$-$C_2$-$C_3$ | Wt. % | 4.2 | 5.8 | 2.2 |
| $C_4$ | Vol. % | 5.4 | 8.4 | 4.9 |
| $C_5$-EP | Vol. % | 80.2 | 79.6 | 83.7 |
| Benzene | Vol. % | 57.0 | 0.8 | 0.3 |
| Toluene | Vol. % | 2.7 | 46.2 | 1.7 |
| Xylenes | Vol. % | — | 8.6 | 50.4 |
| $C_9$+ Aromatics | Vol. % | — | 1.0 | 7.6 |
| Paraffin Cyclization(1) | % | — | 25.0 | 19.0 |

(1) Based on conversion of Naphthenes only to Aromatics.

### Operating Conditions

The operating conditions using RD-150 catalyst may be varied over the following ranges: 200-750 psig, 850-970 F reactor inlet temperature, 1 to 5 weight hourly space velocity based upon fresh feed, and 3-10 molal gas recycle ratio. The corresponding catalyst life and the length of the processing cycle will then be dependent upon the selection or the operating conditions for the given stocks and the desired reformate qualities.

At the present time three units totaling 35,000 bbl per day capacity are under construction with completions scheduled for 1954 and early 1955. Designs of these units are based upon the 500 psig continuous process with provision for regeneration at intervals ranging from three to six months or longer. Catalyst lives are expected to be in the neighborhood of 200 bbl per pound of catalyst for these units with the charge stocks available and at the anticipated octane levels. Similarily for these conditions the catalyst costs will be approximately $0.03 per bbl of naphtha processed. Presently designed commercial units are intended primarily for motor gasoline operation, however, suitable provisions have been made so that the reforming severity can be increased if the production or aromatic chemicals become warranted by market conditions.

### Summary

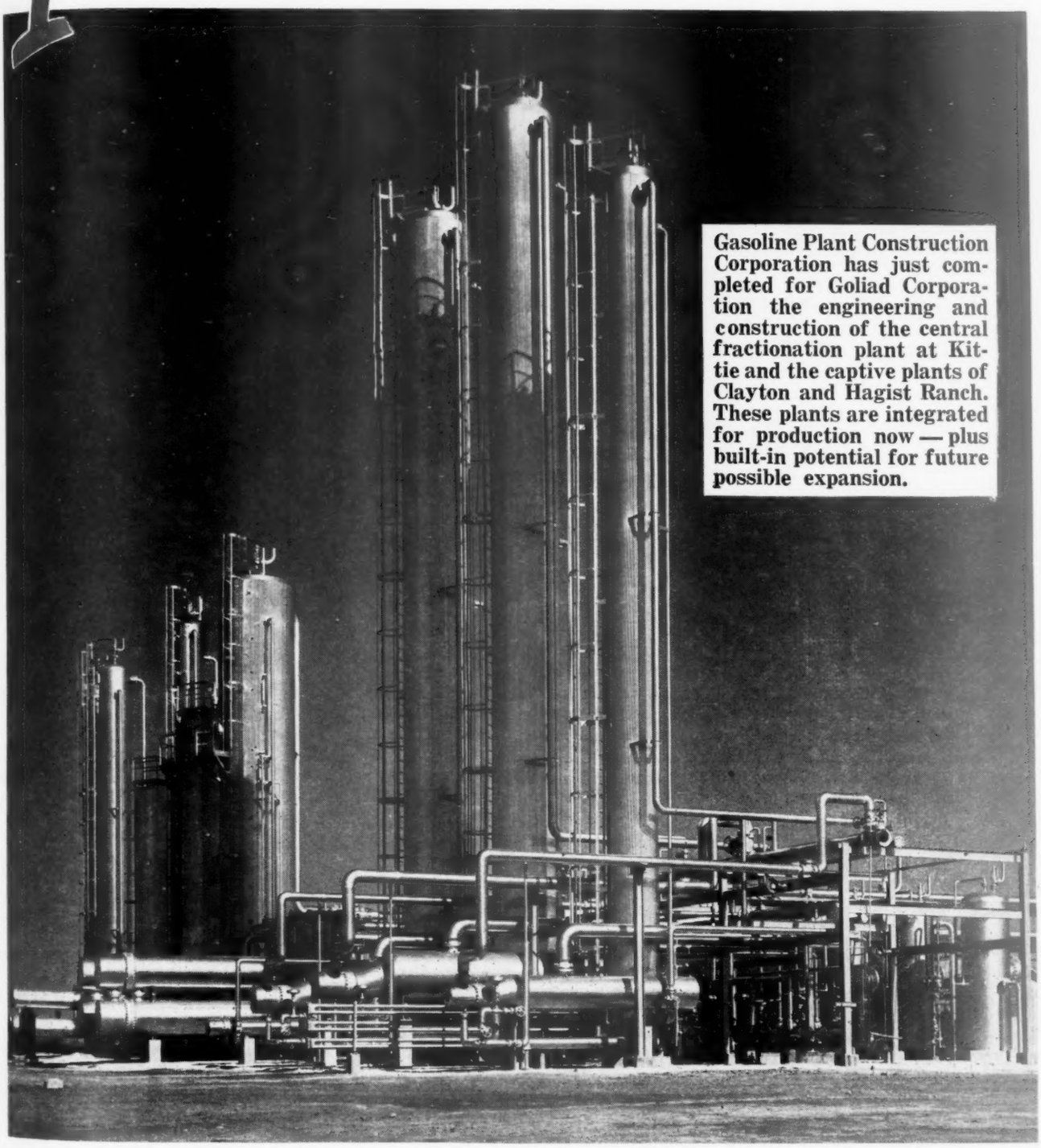
This new reforming process utilizing the RD-150 catalyst permits considerable latitude in both design and operation. This will insure efficient and economical operation for varying market conditions and with varying quality feed stocks. Resistance of the catalyst to permanent posioning and its ease of regeneration allows the catalyst to be maintained at nearly virgin activity levels throughout its life. Regenerative characteristics of the catalyst extends its range of application to all types of operations and thus considerable inherent flexibility is built into the process. * * *

## Distillation Units Electronically Controlled

Anglo-Iranian Oil Company's $126,000,000 Aden refinery, now under construction at the southern tip of Arabia, will be the first refinery in the world in which crude distillation units are electronically controlled, the company announced. First of two big control desks, one for each of the refinery's two 60,000 bbl-a-day distillation units, has been shipped from London, the company said.

Guided by a colored flow diagram of the distillation unit with indicator controls mounted at appropriate points, an operator from an air-conditioned control room overlooking the plant will be able to regulate the flow, pressure, level and temperature of the various oil-streams passing through the units, it was explained. Miniature recorders will provide a record of the trends in temperature, flow and presure, while quantities of various products from the unit will be calculated by meters mounted in the sidewings of the desk.

# INTEGRATION Along the Wilcox Trend



**Gasoline Plant Construction Corporation has just completed for Goliad Corporation the engineering and construction of the central fractionation plant at Kittie and the captive plants of Clayton and Hagist Ranch. These plants are integrated for production now — plus built-in potential for future possible expansion.**

ENGINEERS • DESIGNERS • CONSTRUCTORS

**GASOLINE PLANT CONSTRUCTION CORP.**

NIELS ESPERSON BLDG., HOUSTON WILSON TOWER, CORPUS CHRISTI

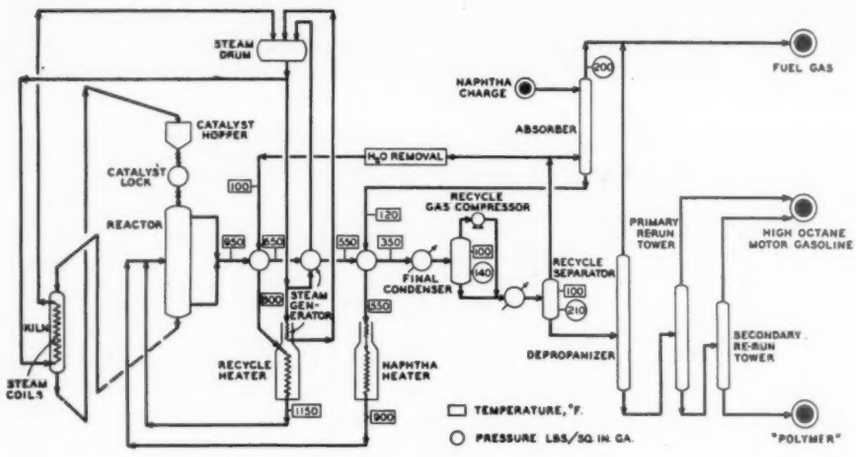



**FIG. 1. Diagrammatic flow sheet of Thermofor catalytic reforming process.**

# T. C. REFORMING*

## *Regeneratable chromia-alumina gel bead catalyst in moving bed operates at 175 psig and up to 1000 F*

RECOGNIZING the need for a catalytic reforming process which could be used for upgrading all types of low-octane gasolne components into premium fuels in the F-1 octane-number range of 98-100, and which could be equally well adapted to the production of aromatic blending stocks, Socony-Vacuum Oil Company several years ago initiated a development program which resulted in the Thermofor Catalytic Reforming (TCR) Process. This process was announced to the industry at the Third World Petroleum Congress in 1951.

The TCR process employs a synthetic chromia-alumina bead catalyst which circulates through a moving-bed system comprising a reactor and a kiln; thus provision is made for continuous reaction, with regeneration of the catalyst. As implied by the term "Thermofor," the design of this system embodies many of the principles applied successfully in the well-known TCC (Thermofor catalytic cracking) process over the past 10 years.

A number of charge stocks were evaluated in the laboratory pilot plant program. Included were both straight-run naphthas and blends thereof with thermal gasolines — these stocks boiling chiefly in the 200-400 F range. One stock, which comprised approximately equal parts of straight-run and high-sulfur coker naphthas from Wilmington, California crude, required reforming for sulphur removal as well as for octane-number improvement. All stocks were selected from normal refinery operations. This laboratory program proved that the process was readily adaptable to the high sulfur high olefin stocks for which it was primarily designed.

Extensive process design and economic studies based on the pilot plant program demonstrated that the optimum operating conditions are largely independent of the feed stock properties. The final result of these studies led to the selection of a single reactor, without reheat, which employs gas recycle in the amount of approximately 6 mols of recycle gas per mol of naphtha, with operation at a pressure of about 175 psig and at a space velocity of 0.7. Average reactor temperature may range up to 1000 F for reforming to an F-1 octane number of 100 upon the addition of 3 ml TEL per gallon.

A schematic flow diagram for a commercial TCR unit is illustrated in Fig. 1. Starting with the reactor, the effluent therefrom flows through heat exchange, with recycle gas and naphtha, to a final condenser. The condensate and gas are then separated in a receiver which operates approximately at a pressure of 140 psig and a temperature of 100 F. The gas from this receiver is compressed to approximately 210 psig by the recycle-gas compressor. The condensate is pumped up to the same pressure, after which both are recontacted and cooled before they flow to the recycle separator. The condensate from the recycle separator is pumped to a depropanizer or to other suitable stabilization facilities.

The net gas production flows to an absorber, and thence to the fuel line. Naphtha charge is pumped over the absorber, in order to obtain the desired recovery of light hydrocarbons from this gas; and it is pumped from the base of this absorber through heat exchange, thence through the naphtha heater which raises the temperature to approximately 900 F, and finally into the reactor. The recycle gas, which is the main stream to leave the recycle separator, passes first through a dryer, next through heat exchange with the reactor effluent, and finally through the recycle heater which heats this material to a temperature of approximately 1150 to 1200 F. The hot recycle gas mixes with the heated naphtha just before both enter the reactor.

Catalyst flows downward through the reactor in a compact moving bed. Inasmuch as the catalyst flow is comparatively small, ranging from approximately 5 to 50 tons per hour for units which have throughputs up to 20,000 bbl per stream day, it may be transported from the base of the reactor to the top of the regenerator with bucket elevators or with other suitable lift equipment. The regenerator is a conventional multizone type of Thermofor kiln, similar in operating principle to those installed on TCC units. This type of kiln is well suited to the low catalyst circulation requirements of the TCR process, and it does not embody new or unusual design features.

The catalytic section of TCR units is very similiar in general arrangement to the catalytic section of the smaller size bucket elevator type TCC units, a number of which have been built in the 3000 to 5000 bbl per day range. Just as in these TCC units, the TCR catalytic section is arranged with the reactor and kiln side by side. Auxiliaries to the reactor-kiln system include a hot catalyst storage bin for holding the catalyst during a shutdown, a fresh catalyst bin, and an elutriator for removing fines from a continuous satalyst slip stream.

The TCR kiln operates at substantially atmospheric pressure. A kiln for

*Socony Vacuum Oil Co., Inc.

a 15,000 bbl per day TCR unit would normally be designed to burn about 2000 lb of coke per hour, with a catalyst circulation of approximately 25 tons per hour. Regeneration is accomplished in several burning stages, with cooling between stages. Inasmuch as TCR catalyst burn quite rapidly, the average regeneration temperature is maintained in the range of 800 to 1000 F, which is approximately 200 F lower than the comparable temperatures in a TCC kiln. Control of burning is accomplished mainly by regulation of the combustion-air temperature to the various zones. Secondary control is provided by regulation of the cooling coils between burning zones. Just as in TCC units, the cooling coils also serve for steam generation.

The reactor for a 15,000 bbl per day TCR unit is approximately 11 ft 0 in. in diameter, and it is designed to operate at a pressure of 175 psig. The naphtha and recycle-gas feed enter the center of the reactor and flow upward and downward to suitable vapor-disengaging sections. The two vapor streams which leave the reactor are combined before they enter the heat exchange system.

The commercial reactor is provided with a pressure lock system. The operations of filling, pressuring, emptying and depressuring are controlled by a cycle timer which operates on a 10-min cycle. The valves are 8 in. plug cocks which are equipped with stellited plugs and seats with special lubrication grooving; they are of the same design as those used in the 50 bbl per day unit.

Spent catalyst is purged in the bottom of the reactor; and, after it has left the reactor, it is transferred to a bucket elevator.

Various types of catalyst are known to be selective for the reforming of petroleum naphthas. Of these, the one finally selected for use in the TCR process was a synthetic chromia-alumina gel. This type of catalyst has many desirable characteristics:

1. It has a "high octane-number ceiling," i.e., it permits reforming to high anti-knock quality (F-1 100 octane number, or higher, upon the addition of 3 ml TEL per gallon) with good yields.

2. It operates with low hydrogen partial pressure.

3. It can be readily regenerated. This can be accomplished by burning off the coke deposits. Thus wide latitude is provided for the reforming of all types of stocks, particularly the high coke-forming thermally-cracked stocks, as well as broad boiling-range straight-run stocks.

4. It promotes excellent desulfurization, and the sulfur is eliminated mainly as hydrogn sulfide in the reforming gas — thus avoiding a potential air-pollution problem.

5. Finally, the catalyst is in bead form, and it possesses the high physical strength and ruggedness of the widely used TCC bead cracking catalyst (Fig. 1). A plant for the manufacture of this catalyst has been constructed at the Paulsboro, New Jersey, refinery of Socony-Vacuum. This plant is currently operating to produce the requirements of the commercial TCR units.

As a result of the experience gained in the operation of a laboratory 50 bbl per day semi-commercial unit, it was possible to proceed with design and engineering of commercial units. Two 19,000 bbl per stream day units are under construction with completion expected later this year. * * *

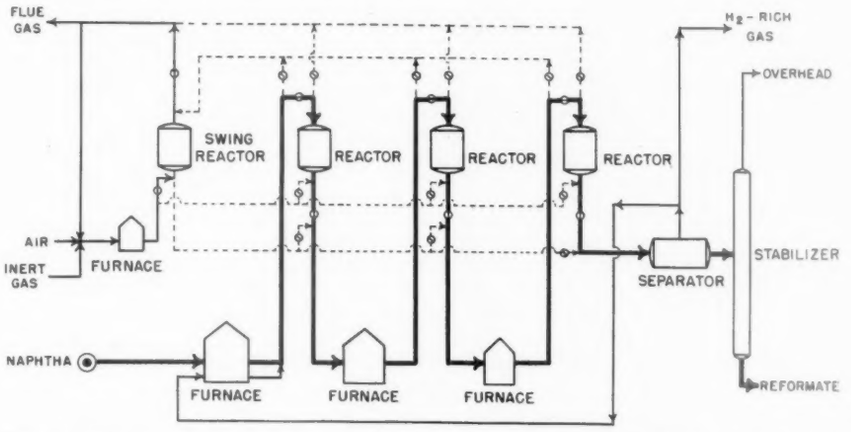



**FIG. 1. Flowchart showing the essential steps in Ultraforming naphthas, also catalyst regeneration routine.**

# ULTRAFORMING

## *Low-pressure process uses cyclic regeneration by novel technique*

**W. J. BIRMINGHAM***

ULTRAFORMING, a new catalytic reforming process, was recently offered to refiners by the Standard Oil Company (Indiana). Ultraforming is a low-pressure process using an improved platinum catalyst in fixed beds. These beds are regenerated cyclically by a novel technique that keeps catalyst performance at its peak. Use of a swing reactor makes it possible to regenerate without interrupting reforming operations. Low-pressure operation and cyclic regeneration by the Ultraforming technique offers three cost-saving advantages over conventional platinum-catalyst processes: Higher yields, higher octane numbers, and greater flexibility.

### Background

Before World War II, thermal reforming of virgin naphthas to produce gasoline of higher octane numbers was practiced by many refiners, but with severe yield penalties and octane-number limitations. Later, catalytic processes were developed that gave better yields and higher octane numbers. Hydroforming over molybdena-on-alumina catalyst in fixed-bed reactors was the first such process to be widely adopted. Pan American Refining Corporation, a subsidiary of Standard Oil Company (Indiana), placed the first commercial hydroformer in operation in 1940. This process raised octane number largely by converting naphthenes to aromatics; it became the primary producer of toluene during World War II.

Still greater increases in yields and octane numbers became feasible in recent years with the adoption of platinum catalysts. In conventional proc-

*Standard Oil Company (Indiana).

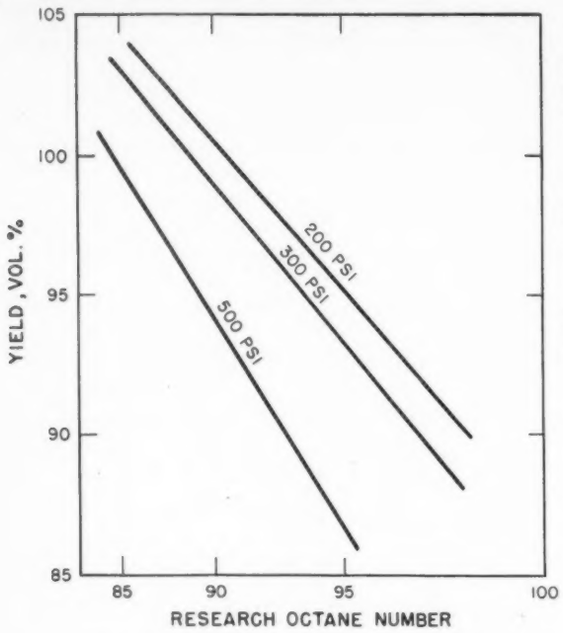



FIG. 2. Curves showing relationship of operating pressure, octane number, and yield of 10-lb product for Mid-Continent charge to Ultraforming.

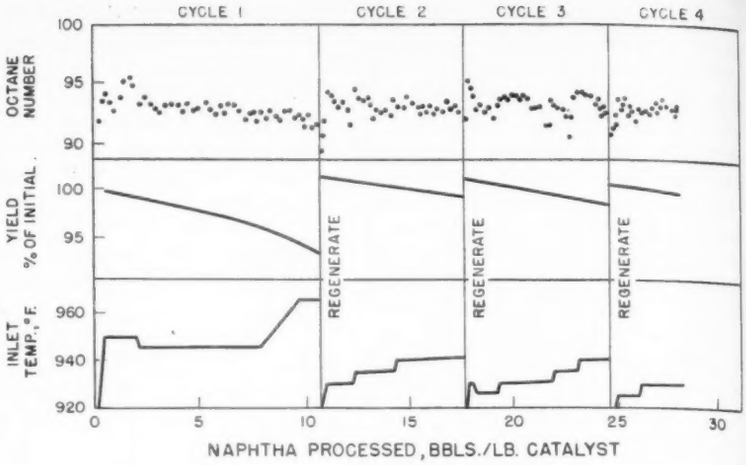



FIG. 3. Chart showing several cycles of an Ultraforming test on Mid-Continent naphtha.

esses using platinum, however, relatively high pressure is used and the catalyst is regenerated seldom if at all. Such processes simplify equipment needs, but at a high cost in flexibility and ultimate gasoline yields and octane numbers. Only through lower pressure and cyclic regeneration of the catalyst can the full possibilities of platinum reforming catalyst be realized. A major effort in process development by Standard Oil Company (Indiana) has culminated in a low-pressure regenerative process — Ultraforming.

### Description of Processing

A flow diagram of the Ultraforming process is shown in Fig. 1. In this figure, catalyst in the swing reactor is being regenerated, while naphtha is being processed in the other three reactors.

Naphtha feed and hydrogen-rich recycle gas are passed through a furnace where they are heated to reaction temperature. The feed and recycle gas are then mixed and passed through three reactors in series. The predominant reactions in Ultraforming are endothermic and cause a large drop in temperature across each reactor. Reheat furnaces are therefore installed between reactors to return the mixture to reaction temperature. Effluent from the final reactor is condensed and separated into a liquid stream and a hydrogen-rich gas. The liquid is stabilized to the desired vapor pressure and withdrawn as finished reformate. Part of the gas is recycled; the rest can be used as a source of hydrogen for other processes or as fuel.

When catalyst activity in a reactor declines, that reactor is temporarily isolated from the naphtha-processing system and its place is taken by the swing reactor. Naphtha processing continues uninterrupted while catalyst in the isolated reactor is regenerated. After regeneration, the reactor is placed back on stream and the swing reactor is held in readiness until catalyst in another reactor needs regeneration.

The single swing reactor is adequate because the time required for regeneration is considerably less than that for processing naphtha. Manifolding minimizes the number of pipes and valves needed in substituting the swing reactor for each of the other reactors. Thus Ultraforming combines cyclic regeneration with simple plant design.

### Low-Pressure Operation

Ultraforming was developed to take advantage of the increased yields of gasoline and the higher octane numbers that can be reached by operating at pressures in the range of 200-300 psi. Increased yields provide the refiner with a more economic process for upgrading motor fuel. Higher octane numbers give the refiner an important margin in motor-fuel quality.

The increased yields are illustrated in Fig. 2, in which yields of gasoline having a 10-lb Reid Vapor Pressure are plotted against Research octane number at different pressures. By reducing pressure from 500 to 300 psi, the yield of unleaded 95-octane gasoline is increased about 7 vol per cent. Further reduction to 200 psi increases yield another 2 per cent. The higher yields at lower pressures result from (1) decreased degradation of naphtha to butane and lighter gases, and (2) lower vapor pressure of reformate, which allows more butane to be added to reach 10-lb RVP.

Higher octane levels characteristic of lower pressures can be illustrated with a Mid-Continent naphtha reformed under constant conditions other than pressure:

| Reactor pressure, psi | Octane number, Research, unleaded |
|---|---|
| 500 | 85.0 |
| 400 | 88.3 |
| 300 | 90.6 |
| 200 | 92.9 |

A plant of given capacity operating at low pressure can therefore produce gasoline of much higher octane number. Moreover, at the same octane level, a plant operating at low pressure can produce higher yields and can either process more naphtha or operate with less catalyst.

### Novel Regeneration Technique

Before development of Ultraforming, the most serious problem associated with lower pressures was the more rapid deposition of coke on the catalyst. The amount of coke formed is small, but it causes a rapid decline in catalyst activity and in gasoline yield. As a result, cycle length is greatly reduced, and to make low pressure economically attractive the catalyst must be restored to full activity between cycles. However, with conventional reforming processes, regeneration, if used, merely burns carbon deposits from the catalyst and does not fully restore activity. Thus the catalyst can be used for only a few cycles. This has been the principal deterrent to commercialization of low-pressure reforming processes.

The solution of this problem is an

**TABLE 1. Ultraforming of three different naphthas.**

| FEED | Gulf Coast | | Mid-Continent | | Arkansas | |
|---|---|---|---|---|---|---|
| ASTM DISTILLATION, °F | | | | | | |
| Initial | 202 | | 206 | | 149 | |
| 10% | 250 | | 237 | | 172 | |
| 50% | 305 | | 274 | | 244 | |
| 90% | 356 | | 324 | | 322 | |
| End Point | 394 | | 361 | | 377 | |
| COMPOSITION, VOL. % | | | | | | |
| Paraffins | 26.0 | | 50.0 | | 77.0 | |
| Naphthenes | 55.5 | | 41.5 | | 15.0 | |
| Aromatics | 18.5 | | 8.5 | | 8.0 | |
| Octane, Research, Unleaded | 59.4 | | 44.5 | | 45.3 | |
| OPERATING PRESSURE, PSIG | 300 | | 300 | | 300 | |
| PRODUCTS | | | | | | |
| $C_5$+ BASIS | | | | | | |
| $C_5$+ octane, Research, unleaded | 90 | 100 | 85 | 95 | 85 | 90 |
| $C_5$+ RVP, lb | 2.0 | 3.3 | 2.4 | 2.8 | 5.4 | 6.0 |
| $C_5$+ yield, vol. % | 91.8 | 83.8 | 89.9 | 82.8 | 84.5 | 80.0 |
| Butanes, vol. % | 2.7 | 6.2 | 3.1 | 5.5 | 7.1 | 9.3 |
| Dry gas, wt. % | 3.4 | 7.2 | 4.8 | 8.4 | 7.5 | 9.8 |
| Hydrogen, CF/B | 900 | 1100 | 970 | 1150 | 540 | 590 |
| 10-LB. RVP BASIS | | | | | | |
| 10-lb Octane, Research, unleaded | 90 | 100 | 85 | 95 | 85 | 90 |
| 10-lb yield, vol. % | 105.7 | 93.2 | 103.1 | 93.3 | 91.8 | 85.7 |

important achievement of the Ultraforming process. A new regeneration technique has been developed that goes beyond the mere removal of carbon; this new technique completely restores the catalyst to fresh condition. Furthermore, the catalyst developed for this process may be repeatedly regenerated. Regeneration by the Ultraforming technique thus makes it possible to use the catalyst for many cycles and thereby realize the advantages of low-pressure reforming.

The Ultraforming regeneration technique has other advantages. It permits a wide range of operating conditions; it permits recovery from operating upsets, and it permits use of feed stocks varying widely in character. If excessive coke is formed on the catalyst for any reason, the catalyst can be regenerated completely to restore operations to normal. Ultraforming catalysts have been subjected to temperatures as high as 1130 F, to pressures as low as atmospheric, to periods of no hydrogen recycle, and to charge stocks boiling as high as 540 F. Although the catalysts were severely deactivated in each case, catalyst activity was restored completely by the Ultraforming regeneration technique.

### Operating Data

Typical operating data from an Ultraforming pilot plant are presented in Fig. 3. Octane numbers, yields, and inlet temperatures are shown for almost four cycles of a pilot plant test now in progress. The octane level of 93 is maintained by slight increases in temperature from time to time to compensate for decline in catalyst activity. Thus, inlet temperature gives a direct indication of catalyst activity. Yield is expressed as per cent of the yield obtained with a new catalyst.

Cycle 1 was continued longer than would be the case commercially to determine whether yield or activity would limit cycle length. Yield decline was found to be limiting, and cycles 2 and 3 were ended when gasoline yield was 2 per cent below the fresh-catalyst level.

Fig. 3 illustrates the effectiveness of the regeneration technique and the stability of Ultraforming catalyst. From cycle to cycle, there is no loss in initial gasoline yield or increase in the rate of yield decline. Activity of the catalyst has actually increased with each regeneration. Although this improvement can not be expected in all cases, it is a forceful illustration of unusual effectiveness of the Ultraforming regeneration technique.

### Yields

Yields obtained by Ultraforming three naphthas of high, moderate, and low naphthene content are shown in Table 1. The Gulf Coast naphtha, containing 55 per cent of naphthenes, produced more than 93 per cent of 10-lb-RVP gasoline at the 100-octane level. The Mid-Continent naphtha, containing 41 per cent of naphthenes, gave more than 93 per cent of 95-octane product. The highly-paraffinic Arkansas naphtha with only 15 per cent of naphthenes gave more than 85 per cent of 90-octane gasoline.

Results with the highly-paraffinic naphtha demonstrate the unusual effectiveness of Ultraforming with even the least-favorable charge stock. This ability arises from the nature of the Ultraforming catalyst. Most platinum catalysts have good activity for conversion of naphthenes to aromatics. Even total conversion of naphthenes to aromatics, however, would not be sufficient to produce the high-octane motor fuels projected for the future; 100 per cent conversion of naphthenes in the Mid-Continent naphtha would produce reformate of only 80-85 octane number. A good reforming catalyst must also convert paraffins to aromatics. The ability of Ultraforming catalyst to do so makes possible the production of high-octane reformates in high yield from even low-naphthene, high-paraffin feed stocks. The excellence of Ultraforming catalyst for aromatization of paraffins also makes the process attractive for producing aromatic concentrates from selected fractions of virgin naphthas.

### Catalyst Cost

Extensive studies show that the life of Ultraforming catalyst may be well above 100 bbl of feed per pound of catalyst. The replacement cost is about $4 per pound, including charges for recovering platinum from used catalyst. Catalyst cost should therefore be less than 4 cents per barrel—about the same as that of cracking catalyst. The catalyst is supplied by the American Cyanamid Company, who cooperated in developing it.

### Commercial Status

Six Ultraformers are being installed. Three are under construction: a 9000-bbl per day unit for Standard Oil at Wood River, Illinois; a 6800-bbl per day unit for the Pan-Am Southern Corporation at El Dorado, Arkansas; and a 21,000-bbl per day unit for the Pan American Refining Corporation at Texas City, Texas. Three others, with a combined capacity of 21,300-bbl per day, are in the design stage. Two will be built at refineries of Standard Oil at Casper, Wyoming, and Sugar Creek, Missouri; the other is being designed for Canadian Petrofina, Ltd., at Montreal.

Licenses for the Ultraforming process are available from Standard Oil for a reasonable royalty. Such licenses give operating rights under relevant patents of the Standard Oil Company (Indiana), including those covering future improvements. Licensees and approved contractors have access to the company's confidential information.

* * *

### New-Type Cat Reformer

A new type catalytic reformer is rapidly taking shape at Pure Oil Company's Heath refinery at Newark, Ohio. Designed and being erected by The M. W. Kellogg Company, the reformer represents the first commercial installation of the special process developed by Kellogg to utilize the new regenerative platinum catalyst, RD-150. The plant will process 3000 bbl of naphtha daily, converting the low (about 33) octane feed to high octane gasoline which will rate about 98 octane with 3 cc of TEL.



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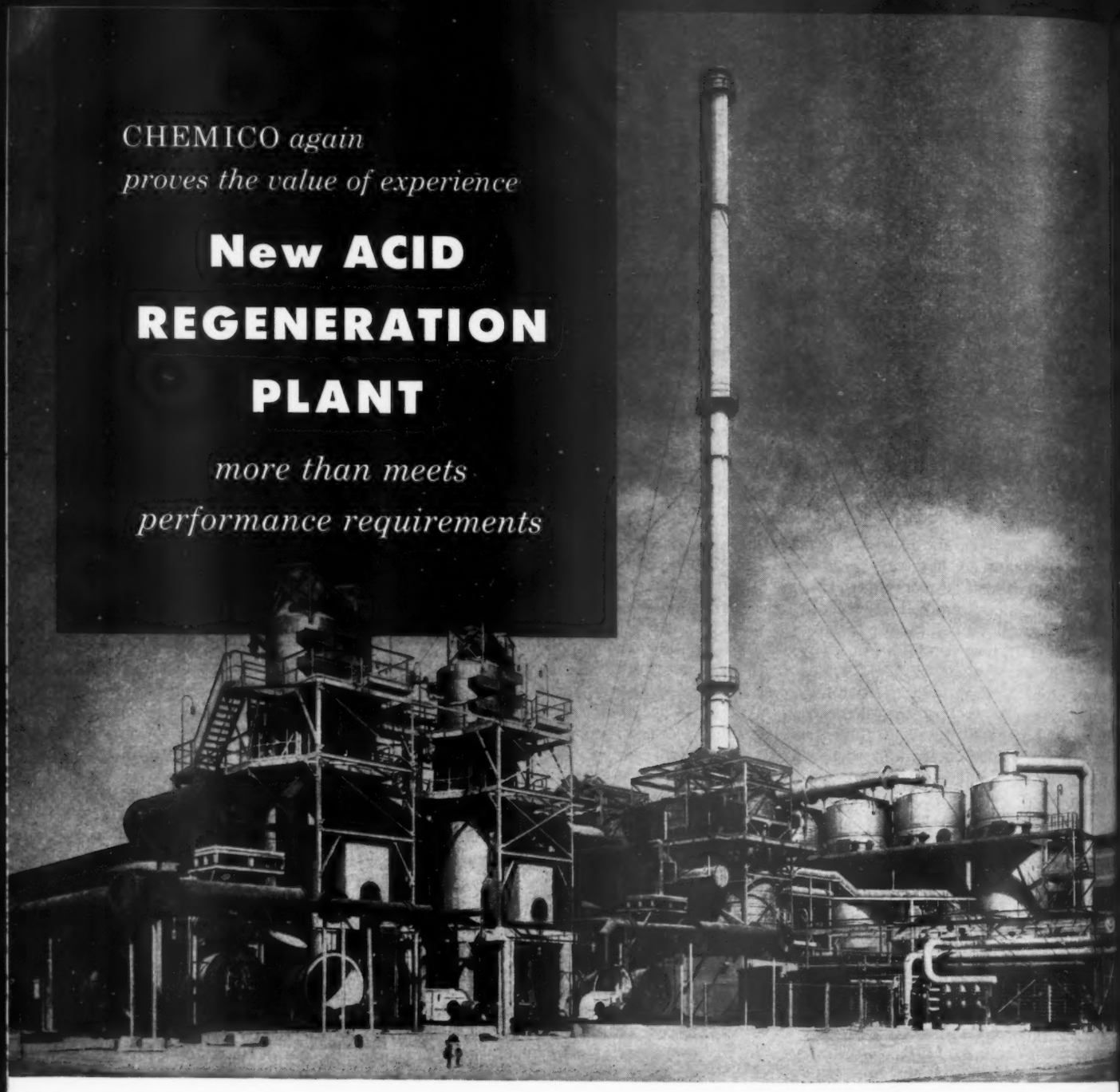

For 39 years Chemico has been supplying industry's needs for chemical plants of various types. This new plant designed and built for Consolidated Chemical Industries in Baton Rouge, Louisiana, for the production of fresh acid from waste refinery sludges is a recent example.

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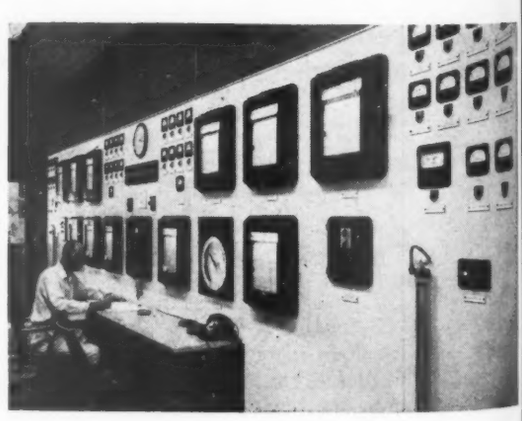

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# Refining Construction Going Strong in 1953-54

ARCH L. FOSTER*

CONSTRUCTION of refinery, natural gasoline, and petrochemical capacity, although total expenditures may or may not be down from 1952 or earlier post-war years, is still one of the greatest factors in our continued industrial and commercial advances. Estimated summaries from more than 500 construction items listed in the accompanying tabulation (part of the foreign record is not included here) indicate that a very conservative figure for building completed or begun since January 1, 1953, is $4,500,000,000. Data on petrochemicals are presented in another tabulation elsewhere in this issue.

Among individual processes or refining operations catalytic reforming of low-grade naphthas continues to be the largest single item in refinery construction. A great deal of catalytic cracking capacity is still under construction or design, or has been completed during this 14-month period (January 1, 1953 to March 1, 1954), but cracking capacity was more nearly at the saturation point at the beginning of the period than was reforming. Growth of petrochemical demands for raw materials and/or intermediates hastened also the construction of cat reforming and correlated units, especially aromatics concentration capacity.

Among the interesting developments not given too great attention publicity-wise is that of the construction of "modern" coking facilities for processing heavy residual oils. As is well known throughout the industry, the consumption of heavy fuel oil, which reached its peak during the 1930's and early '40's by reason of the conversion of railroad and similar power units from solid to heavy-liquid fuels, has progressed further along with the locomotive-diesel development. Railroad power has been converted rapidly to diesel-electric power, consuming distillate fuels instead of residuals, leaving the heavy stuff on the refiners' hands as an increasingly serious liability. By destructive distillation the refiner comes up with a cracked distillate of greater value either for thermal or catalytic cracking stock, or as salable distillate fuel for various uses; again a potential but not yet actual drug on the market is the coke remaining in the coking stills, which so far is sold to consumers in the metal production industry, and for some other lesser uses. Recently a continuous coking unit has been made feasible on commercial scale; a fluid type unit that yields coke in mobile granules is going into large-scale application, and older methods such as the multiple drum intermittent-continuous type are receiving attention.

Although obviously the construction curve for refining must "level off" as time passes, the increase in consumption of petroleum products will aid in holding this curve higher than otherwise might be the case. The effect of the coming on stream of European and Asiatic refining capacity now under construction will be of course to reduce export sales from this country. The combined effect of all these factors is not possible of accurate evaluation at present, but all indications are that capacity expansion and replacement of older, obsolescent units will maintain a high building rate during the next two years at least.

Only a part of the foreign construction data are included in the accompanying table and a later report will bring this phase up-to-date.

*Editor, Refining and Petrochemicals.

## ROSTER OF REFINING, NATURAL GASOLINE, AND PETROCHEMICAL PLANTS

Started or completed between January 1, 1953 and March 1, 1954

| Location and Company Name | Kind or process | Capacity | Cost, approx. ($ mill.) | Date comp'd[1] or operating[2] | Builder |
|---|---|---|---|---|---|
| Hammond, Ind. Alloy Asphalt and Refining | asphalt | 50mm. gal/yr | $2. | March 54[1] | Owned by Byerlite and Allied Mat. |
| Baton Rouge, La. Allied Chem. & Dye | trifluorochloroethylene unit. | — | — | 54 | — |
| Tonawanda, N. Y. Semet-Solvay Div., Allied Chem. & Dye | ethylene and polyethylene | 20mm. lb/yr | — | Jan. 54[2] | Lummus |
| Williston Basin, ND Amerada Pet. | Natural gasoline plt. | — | $10. | — | — |
| Cincinnati, Ohio A. Bit. & A. | asphalt plant | — | $4. | Spring 54 | — |
| Mt. Pleasant, Tex. American Liberty | TCC gas fract. feed prep. gas con., Poly. revamp | 5120b/d | $2.7 | Late 53 | Fluor |
| Mt. Pleasant, Tex. American Liberty | treating unit | — | $3. 5 | March 54 | Fluor |
| Toledo, Ohio A. Min. Sp. (Pure) | alkylate | 1450 b/d | — | Early 54 | — |
| Toledo, Ohio A. Min. Sp. | alkylation unit (sulfuric acid) | — | $2.5 | — | — |
| Texas City, Tex. American Oil | cat cracker | — | — | Complete | — |
| Thermopolis, Wyo. Amer. S. & P. | sulfur plant | 200-300 t/d | — | Mid-54[1] | — |
| North Tepatate, La. Anchor Gasoline | gasoline plant | 360 b/d | — | Mid-53 | — |
| Cyril, Okla. Anderson Prichard | catformer unit | 1000 b/d | — | Spring 54 | Blaw-Knox |
| Oklahoma City, Okla. Anderson-Prichard | catformer | 1000 b/d | — | Early 54[1] | Blaw-Knox |
| Aden, Africa Anglo-Iranian | complete refinery | 100,000 b/d | — | Late 54 | — |
| Antwerp,Belgium AIOC-Petrofina | cat poly. cat cracker | — — | — — | Mid-54[1] Mid-54[1] | — — |
| Hamburg, Germany Anglo-Iranian | crude unit, platformer | — | — | Mid-54[1] Mid-54[1] | — |
| Kwinana, Australia AIOC-Austr. Pet. | New refinery | 60,000 b/d | $112. | 54 | — |
| Lavera, France AIOC and AGHP | Platformer | 5000 b/d | — | 54 | — |
| Mombasa, Africa AIOC-Shell | complete refinery | — | $196. | Late 54 | — |
| Schindler plant, Germany-AIOC | furfural lube treater | — | — | Late 54[1] | — |
| Trieste, Italy.Aquila | cat. cracker. TCC | 7000 b/d | $4.025 | Late 54[1] | Sweco |
| Carthage, Tex. Arkansas Fuel Oil | butane and propane rec. | 100 mmcf | — | Mid-53 | — |
| Haughton, La. Arkansas Fuel Oil | gas plant | 60 mmcf | — | Complete | — |
| Jefferson, Tex. Arkansas Fuel Oil | LPG rec. | 31 mmcf | — | Early 53 | — |
| Catlettsburg, Ky. Ashland | vacuum unit crude tower | 11,000 b/d 7,000 b/d | — — | — — | Catalytic Catalytic |
| Atreco, Texas Atlantic | cat. reforming | 7500 b/d | — | — | Ferguson |
| Lovington, N. M. Atlantic | nat. gaso. plant (26 Co. involved) | 25 mm cf/d | — | — | — |
| Philadelphia, Pa. Atlantic | Orthoflow cat. cracking | 45,000 b/d | — | 53 | Kellogg |
| Philadelphia, Pa. Atlantic | catformer | 11,000 b/d | $4. | Early 53 | Badger Division |
| Philadelphia, Pa. Atlantic | two stage pipe still, cat; alky; poly units | 50,000 b/d | $5.6 | 53 | Badger Division |
| Philadelphia, Pa Atlantic | $H_2SO_4$ alkylation | — | — | Spring 54[1] | Kellogg |
| Philadelphia, Pa. Atlantic | Orthoflow cat cracker | 45,000 b/d | — | Mid-54[1] | Kellogg |
| Philadelphia, Pa. Atlantic | two stage crude dist. | 45,000 b/d | — | — | Foster Wheeler |
| Detroit, Mich. Aurora Gasoline | basic refining | — | $.4 | — | — |
| Elsie, Michigan Aurora Gasoline | Platformer | 1500 b/d | — | Late 53[1] | Procon, Inc. |
| Newark, N. J. Baker-Sinclair | catalyst (platinum) | — | — | Early 54 | — |



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## ROSTER OF REFINING, NATURAL GASOLINE, AND PETROCHEMICAL PLANTS — Continued

Started or completed between January 1, 1953 and March 1, 1954

| Location and Company Name | Kind or process | Capacity | Cost, approx. ($ mill.) | Date comp'd[1] or operating[2] | Builder |
|---|---|---|---|---|---|
| Bay City, Mich. Bay Refining | cat. poly. TCC unit cat. cracker | 300 b/d 6000 b/d | $3. | Fall 54[1] | Sweco |
| Denver, Colo. Bay Petroleum | fluid cat. crack crude expan. | 3500 b/d 6000 b/d | $1.9 — | Jan. 53 — | Procon Procon |
| Denver, Colo. Bay Petroleum | fluid catformer cracker | 3500 b/d | — | Sept. 53[2] | UOP (design) |
| Denver, Colo. Bay Petroleum | fluid cat cracker | 3500 b/d | — | July 53 | — |
| Saginaw, Mich. Bay Refining | poly., TCC cat cracking | 300 b/d 6000 b/d | $3. | Fall 54[1] | Sweco |
| Ardmore, Okla. Ben Franklin | fluid cat. cracker | 5000 b/d | — | Oct. 53 | Procon |
| Ardmore, Okla. Ben Franklin | cat. cracker, poly | 10,000 b/d | $2. | Summer 53 | Staff |
| Brea, Calif Brea Chemicals | nitric acid plant | — | $2.5 | Late 54 | C. F. Braun |
| Brea, Calif. Brea Chemical | ammonia plant | — | $13. | Mid-54 | C. F. Braun |
| Clarkson, Ontario British-American | ref. additions and Fld. cat. cracker | 8300 b/d | $8. | May 54 | Canadian Kellogg and Barnes |
| Clarkson, Ont. British-American | grease plant | 15mm lb/yr | — | Mid-53 | — |
| Clarkson, Ont. British-American | cat cracker | 8000 b/d | — | Mid-54 | Canadian Kellogg |
| Clarkson, Ont. British-American | grease plant | 42 mm lb | $1.5 | Complete | — |
| Chauk, Burma Burma Oil | complete refinery | 2500 b/d | $1.1 | Jan. 54[1] | — |
| Howard County, Tex. J. R. Butler | natural gasoline plant | — | — | — | — |
| Barber, N. J. California Oil | revamp thermal reformer to cat. ref. | 10,700 b/d | — | 54 | Bechtel |
| Barber, N. J. California Refining | expansion cat. poly. | 47,000 b/d 675 b/d | — — | — 53 | — Hydrocarbon |
| Batangas Bay, P. I. Caltex | refinery | 13,000 b/d | $30. | Late 54[1] | Foster Wheeler |
| Kurnell, Austr. Caltex Refining | new refinery | 22,000 b/d | $56. | 55 | — |
| Vishakapatnam, India Caltex Oil | refinery | 10,000 b/d | — | 55 | — |
| Alberta, Canada Campbell Absorption | natural gasoline plant | — | — | — | — |
| Sarnia, Ont. Canadian Oil | refinery | 20,000 b/d | $18. | Complete | Canadian Kellogg |
| Saskatchewan Canada Southern Oils | refinery | 10-20,000 b/d | $7. $10. | — | — |
| Montreal, Canada Can. Petrofina, LTD | cat. cracker | 5000 b/d | — | Fall 54[1] | Houdry |
| Montreal, Que. Can. Petrofina | refinery TCC-TCR | 20,000 b/d | $20. | Late 55[1] | Kellogg, Lummus |
| Montreal, Quebec Canadian Petrofina | refinery, Houdriflow cat. cracker, cat. poly. dist. unit., vacuum dist. cat. reformer, auxiliary, fac., Hydrodesulfurization. | 20,000 b/d | $20. | Late 55 | Kellogg, Lummus |
| Billings, Mont. Carter Oil | cat. poly. unit and waste heat boiler aux. | 600 b/d | — | Early 53 | Blaw-Knox |
| Billings, Mont. Carter Oil | fluid cat. cracker expansion | 15,000 b/d | — | Late 54 | Braun |
| Billings, Mont. Carter Oil | fluid coking | 3800 b/d | — | Late 54 | Fluor |
| Coyle, Okla, Central Petroleum | gasoline plant | — | — | — | — |
| Blackwell, Okla. Cities Service | natural gasoline | 4800 b/d | $4. | Early 53 | — |
| Blackwell, Okla Cities Service | gasoline plant | 200 m g/d | — | Mid 53 | Hudson Eng. |
| Chicago, Ill. Cities Service | grease making | 8.5 mm lb | — | — | — |
| Crockett Co., Texas Cities Service | natural gas | — | $2.4 | — | — |
| East Chicago, Ill. Cities Service | delayed coker | — | — | 54 | Lummus |
| East Chicago, Ill. Cities Service | naphtha fractionator | 44,500 b/d | — | 54 | — |
| East Chicago, Ind. Cities Service DEL | topping unit | 30,000 b/d | $2. | End 54[3] | McKee |
| East Chicago, Ind. Cities Service | Fluid Hydroformer | 12,780 b/d | $4. | 54 | Kellogg |
| Lake Charles, La. Cities Service | Fluid Hydroformer | 17,250 b/d | $7. | 54 | Kellogg |
| Lake Charles, La. Cities Service Ref. | hydro. feed. prep. | 44,450 b/d | $2. | 54 | Kellogg |
| Lake Charles, La. Cities Service Ref. | cathodic protection system | — | — | Late 54 | Cathodic Protection Service |
| Lake Charles, La. Cities Service Ref. | cathodic protection | 3000 amp | $.2 | Mid 54 | Cathodic Protection Service |
| Lake Charles, La. Cities Service Ref. | vacuum | 26,750 b/d | $4. | 54 | Kellogg |
| Lake Charles, La. Cities Service Ref. | vacuum unit | 26,750 b/d | $2. | 54 | Kellogg |
| Linden, N. J. Cities Service | vacuum unit | 5600 b/d | — | Late 53 | — |
| Pampa, Texas Cities Service | gasoline expan. | — | $.222 | — | Parsons |
| Seminole, Texas Cities Service | plant, natural gasoline | 55 m g/d | $3.2 | — | Delta Eng. |
| Colorado City, Texas Col-Tex Ref. | platformer | 1500 b/d | — | Jan. 54[1] | — |
| St. Mary's Parish, La. Columbian Carbon | furance black plant | 60 mm lb/yr | — | (State (Permit (requested | — |
| Regina, Sask. Canada Consumers Corp. | plant expansion | — | $5.5 | Late 53 | — |
| Phillipsburg, Kans. Consumers Co-Op | cat. crk. unit dist. expansion | 5000 b/d 4000 b/d | $2.6 | Feb 53. Mid-53 | Ref. Eng. Ref. Eng. |
| Regina, Saskatch. Consumer's Co-Op. | mod. & expan. cat. craker, poly. gas & vac. units | 11,000 b/d | $5.5 $8. | April 54 — | Ref. Eng. — |
| Adams Co., Colo. Nine oil cos. incl. Continental Oil | natural gasoline plant | — | — | Late 54 | — |
| Lake Charles, La. Continental Oil | natural gasoline plant | 90mm cf | $1.5 | Early 54 | Hudson Eng. |
| Lake Charles, La. Continental Oil | cat. cracker, platformer, alkylation, etc. | 17,000 b/d 6000 b/d 1000 b/d | $27. | 53 | — |
| Ponca City, Okla. Continental Oil | expansion | None | $7.5 | Mid-54 | Staff |
| Phillipsburg, Kansas Co-Op. ref. | cat. cracker, etc. | 4500 b/d | — | Late 53 | — |
| Corpus Christi, Texas Corpus Christi Ref. | Topping-vacuum units | — | $.175 | — | Tex.-Eng.-Constr. |
| Palestine, Texas Corpus Christi Ref. | overall rebuilding | 4500 b/d | — | — | (Old Inland Ref.) |
| Big Spring, Tex. Cosden | avia.-gaso. facl. | 2650 b/d | $2.9 | June 54 | Treco |
| Houston Texas Crown Central | Houdriformer unit | 5000 b/d | $1. | Oct. 54 | Blaw-Knox |
| Houston, Texas Crown Central | crude topping cat. cracker | 2350 b/d 2400 b/d | $.265 | — | — |
| Pasedena, Texas Crown Central | addition to ref. | — | $.545 | — | — |
| Newcastle, Wyoming Cullen-Head | gasoline plant | 30 mmcf/d | — | Mid-55 | — |
| Tokyo, Japan Daikyo Oil | Houdriflow cat. unit | 4200 b/d | — | Mid-54 | Houdry |
| Pettus, Texas Danaho Refining | TCC cat. cracker w/reform cat. poly. crudeexpan.gasconc. | 3500 b/d 265 b/d 7500 b/d | $2.6 | Nov. 54 | — |
| Baltimore, Md. Davison Chemical | catalyst mfg. | — | $.210 | — | Staff |
| Lake Charles, La. Davison Chemical | catalyst plant | 62 tons | $7. | Early 53 | Consd. Eng. |
| Lake Charles, La. Davison Chemical | catalyst factory | 22,500 t/yr | $7. | Spring 53 | — |
| Cushing, Okla. Deep Rock Oil | lube oil plant | 1050 b/d | $2. | Mar. 53 | Kellogg |
| Eagle Lake, Texas Del Rey | natural gasoline butane and propane | — | — | — | — |
| Memphis, Tenn. Delta Refining | airlift cat. crk. cat. poly.; gas conc.; crude dist. revamp. | 3000 b/d 2000 b/d | $1.8 | — | — Koch |
| Toronto, Canada Dendall Refining | lub. oil compounding, packaging and distrib. plant | — | — | — | — |
| Bakersfield, Calif. Douglas Oil | cat. reforming unit | 2500 b/d | $.5 | Mar. 54 | Parsons |
| Bakersfield, Calif. Douglas Oil | polymerization unit | 100 b/d | $.261 | June 53 | — |
| Houston, Texas Eastern States | coking plant | 13,000 b/d | $4. | — | — |
| Blanco, N. M. El Paso Natural Gas | comp. dehyd. and gasoline plant | 180 mmcf | — | 2nd Qtr. 53 | Staff |
| Gallup, N. M. El Paso Natural Gas | fractionation | — | — | 2nd Qtr. 53 | Staff |
| Lea Co., N. M. El Paso Natural Gas | liquid prod. cap. absorber cap. purification & hydro. | 3380 b/d 185 mmcf 180 mmcf | $2.1 $1.8 | Late 52 Late 52 | Staff Staff |
| San Juan Co., N. M. El Paso Natural Gas | gasoline plant | 4500 b/d | $3. | May 53 | Staff |
| Denver, Colo. Empire Petroleum | crude expan. | 3500 b/d | — | — | — |
| Barrancabermeja; Empresa Columbiana | top. unit, cat cracker gasoline treater alkylation | 30,000 b/d 19,215 b/d 10,000 b/d 1,200 b/d | — | Early 55[1] | Foster Wheeler |
| Antwerp, Belgium Esso Standard, S. A. | complete refinery | 25,000 b/d | $25. | April 53 | — |
| Baton Rouge, La. Esso Standard Oil | warehouse | 40 m ft[3] | — | April 54[1] | W. Kidde Constr. |
| Baton Rouge, La. Esso Standard Oil | aromatics fac. crude distill. cat. cracker crude pipe still. Iso-octyl. & tridecyl mfg. (alcohol) | — 300,000 b/d 31,000 b/d 60,000 b/d — | $51. $.326 | — Early 53 Early 53 54 Early 54 | Staff Kellogg Kellogg — — |
| Bayonne, N. J. Esso Standard | crude dist. atmos. pipe still. | 20,000 b/d 28,500 b/d | — — | — — | Lummus,SOD & Foster Wheeler |

## ROSTER OF REFINING, NATURAL GASOLINE, AND PETROCHEMICAL PLANTS — Continued

Started or completed between January 1, 1953 and March 1, 1954

| Location and Company Name | Kind or process | Capacity | Cost, approx. ($ mill.) | Date comp'd[1] or operating[2] | Builder |
|---|---|---|---|---|---|
| Bayonne, N. J. Esso Standard | wax pipe still | 3500 b/d | — | — | Fluor |
| Bayway, N. J. Esso Standard | crude unit | 60,000 b/d | — | Early 54[1] | M. W. Kellogg |
| Bayway, N. J. Esso Standard | pipe still, hydrofiner | 60,000 b/d<br>20,000 b/d | —<br>— | 54<br>Mid-54 | M. W. Kellogg<br>— |
| Everett, Mass., Esso | fluid cat. crk. | 18,500 b/d | — | Late 53 | Foster Wheeler |
| Everett, Mass. Esso Standard | fluid cat cracker | 24,000 b/d | — | Fall 53[2] | Foster Wheeler |
| Everett, Mass. Esso Standard | asphalt vacuum tower | 13,100 b/d | — | 2nd Qtr. 54 | — |
| Everett, Mass. Esso Standard | propane plant | 870 b/d | — | 2nd Qtr. 54 | — |
| Linden, N. J. Esso Standard | crude pipe still | 60,000 b/d | — | 2nd Qtr. 54 | Kellogg |
| Linden, N. J. Esso Standard | Hydrofining | 21,500 b/d | — | 2nd Qtr. 54 | C. F. Braun Co. |
| Long Beach, Calif. Eureka Refining | cat. cracker | 6000 b/d | $2.2 | — | — |
| Laurel, Mont., Farmers Union Central Exc. | fluid cat. cracker | 5000 b/d | $3.5 | Complete | Ref. Eng. |
| Jensen, Utah First Nat. Pet. | cracking | — | $1.25 | Mid-54[1] | — |
| Buffalo, N. Y. Frontier O & R | cat. cracker<br>gas conc. | 12,000 b/d<br>— | — | End 53[2] | UOP & Staff |
| Cheyenne, Wyo. Frontier Ref. | Plant add. | 6500 b/d | $.717 | Sept. 53 | — |
| Tonawanda, N. Y. Frontier O & R | fluid cat. cracker | 12,000 b/d | — | Early 54[1] | — |
| Lingen, Germany G. E. Raffinerie | houdriflow cat cracker | — | — | Mid-53[2] | Local. |
| Ferndale, Wash. General Pet. | complete refinery | 35,000 b/d | $35. | Aug. 54[2] | Bechtel |
| Torrance, Calif. General Petroleum | depropanizer | — | $.350 | Fall 54 | E & A |
| Torrance, Calif. General Petroleum | TC reforming | 19,000 b/d | $9. | Fall 54 | Bechtel |
| Worland, Wyo. General Petroleum | gasoline ext. and sulfur recov. | 8 mmcf | $4. | — | — |
| Odessa, Texas Gilmore Refineries | new refinery | 50,000 b/d | $40. | — | Ford-Bacon-Davis |
| Lemont, Ill. Globe Oil & Refg. | alkylation unit | 5000 b/d | $4. | Complete | Staff |
| Lemont, Ill. Globe Oil & Refg. | alkylation unit,<br>cat cracker | 5000 b/d<br>10,000 b/d | $4. | April 54<br>April 54 | Staff<br>Staff |
| Lavaca Co., Tex. Goliad Corp. | propane,isobutane, natural gasoline | — | $2.7 | — | — |
| St. Paul, Minn. Great Northern | crude topping<br>cat. cracker<br>cat. reformer<br>cat. poly. | 30,000 b/d<br>7,620 b/d<br>6,000 b/d<br>680 b/d | $26. | — | — |
| Twin Cities, Minn. Great Northern Oil | complete refinery | 20,000 b/d | — | Late 55 | — |
| Corpus Christi, Tex. Great Southern | platformer off.<br>platforming and udex units | —<br>4000 b/d | $5.<br>— | Late 53<br>53 | Fluor<br>Procon |
| Corpus Christi, Tex Great Southern Chem. | platformer<br>udex units | 4000 b/d<br>3490 b/d | — | Jan. 54[1] | Procon |
| Krotz Springs, La Gulf Oil, et al | cycling plant | — | — | Mid-55[1] | — |
| Philadelphia, Pa. Gulf | crude;atmos and vacuum unit<br>sulfur recov.<br>gasoline sweet<br>cat. poly.<br>cat. cracker | 125,000 b/d<br>—<br>40,000 b/d<br>10,000 b/d<br>63,000 b/d | —<br>$1.1<br>—<br>—<br>— | Spring 54<br>—<br>Spring 54<br>Early 54<br>Early 54 | Foster-Wheeler<br>—<br>Gulf<br>Kellogg<br>Kellogg |
| Pt. Arthur, Tex., Gulf | polymerization | — | $2.1 | Complete | Bechtel |
| Pt. Arthur, Tex., Gulf | ethylene unit | 3 bil cf/yr | $12. | Early 55 | Badger Division |
| Pt. Arthur, Tex. Gulf | laboratory, power plant etc. | — | $22. | 54 | — |
| Pt. Arthur, Tex., Gulf | platformer | 29,000 b/d | $8. | Early 55 | Fluor |
| Long Beach, Calif. Hancock—Calif. | aviation gasoline | — | $3. | — | — |
| Long Beach, Calif. Hancock | cat. cracker and facilities | 4200 b/d | $3.5 | Dec. 54 | — |
| Long Beach, Calif. Hancock | TCC unit<br>poly. unit | 4200 b/d<br>350 b/d | $4. | Late 54[1] | — |
| Saskatoon, Canada Hi-Way Refs. | fluid cat.<br>unit-visbreaker, etc. | 2600 b/d<br>3500 b/d | $2.5 | End, 53 | Ref. Eng. |
| Saskatoon, Canada Hi-Way Refs. | cat. cracker | 3000 b/d | $2.5 | Late 53 | Ref. Eng. |
| Saskatoon, Canada Hi-Way Refs. | thermal crack expan. | 15,000 b/d | $5. | Complete | Ref. Eng. |
| Baytown, Texas Humble | cat. light ends recov. unit<br>propane deasphalting unit<br>cat. poly.<br>pipe still (crude) | 37 mmcf<br>19,400 b/d<br>28,000 b/d<br>4500 b/d<br>75,000 b/d | $4.5<br>$6.1<br>$5.4<br>$6.5 | Complete<br>May 54,<br>July, 54<br>July, 54 | Fluor<br>Kellogg<br>Hydrocarbon<br>Foster Wheeler |
| Baytown, Texas Humble | cat. light ends recov. unit | 37 mmcf/d<br>19,400 b/d | $4 | Late, 53 | Fluor |
| Baytown, Texas Humble | propane deasphalting unit<br>cat. poly. | 2800 b/d<br>4500 b/d | $5.<br>$4.8 | Oct., 53<br>54 | Kellogg<br>— |
| Baytown, Texas Humble & Consolidated Chemical | sulfuric acid | — | — | Oct., 54 | — |
| Brazoria Co., Tex. Humble & Southern Production | gasoline | — | $4.5<br>$5. | Late, 53 | Stearns-Rogers |
| Cody, Wyo., Husky | reformer | 1000 b/d | $.760 | Aug., 53 | Grebe & Doremus |
| Cody, Wyo., Husky | catformer | 1000 b/d | — | Mid-53[2] | — |
| Cody, Wyo., Husky | vacuum unit | 6000 b/d | — | — | Staff |
| Venice, Italy IROM Ref. (AIOC) | reformer, thermal. | 7000 b/d | — | — | — |
| Edmonton, Atla. Imperial Oil | lube plant | 2000 b/d | $10. | Mid-55 | — |
| Edmonton, Alta. Imperial Oil | lube plant | 2000 b/d | $15. | Late 55 | — |
| Edmonton, Ont. Imperial Oil | fluid cat cracker | — | — | Mid-53 | Foster Wheeler |
| Imperoyal, N. S. Imperial Oil | new refinery | 41 m b/d | $25-30 | 55 | — |
| Montreal East, Ont. Imperial Oil | plant expansion, dist. unit | 12 m b/d | $10. | Early, 54 | — |
| Sarnia, Ontario Imperial Oil | plant expansion-cat. cracker, distillation | — | $20. | Late, 54 | — |
| Sarnia, Ont., Imperial | laboratory, shops, etc. | — | $6. | Early, 54 | — |
| Wrenshall, Minn. International Refs. | skim-cat. cracking | 11,500 b/d | $7. | Nov., 53 | — |
| Meraux, La., Ingram Prod. | platformer, etc. | 3500 b/d | $4. | Spring, 54 | Procon |
| Mereaux, La., Ingram | ref. modernization | 8000 b/d | $2.5 | March, 54 | Procon |
| Ioco, B. C. Imperial Oil | cat. cracker, pipe still | 10.5 m b/d | $13.5 | Fall, 53 | Canadian Bechtel |
| Montreal, Quebec Imperial Oil | 25% cap. increase | 12 mb/d | $10. | Early, 54 | — |
| Regina, Sask, Imperial | mod. and expan. | 2500b/d | $7. | Early, 54 | — |
| Sarnia, Imperial | fluid cat. cracker, dist. light ends recov. | 71mb/d | $14.6 | Early, 53 | Can. Kellogg |
| Sarnia, Imperial | 30 storage tanks | 45 mmb/d | $5.5 | Fall, 53 | Horton Steel, Toronto Iron Works |
| Sarnia, Ontario | quality control lab. packing and shipping plt. and mech. shops | — | $6. | 54 | Canadian-Bechtel |
| Winnipeg, Manitoba Imperial | cat. poly. plant | 250 b/d | $.750 | May, 54 | — |
| Kamloops, Br. Col. Refinery Operators | refinery | 5000 b/d | $6. | 54 | — |
| Kamloops, Br. Col Kamloops Ref. Synd. | complete refinery | 2500 b/d | $3. | Early, 54 | W. M. Barnes & Company |
| Moore Co., Texas Kerr-McGee Oil | natural gasoline | 55 mm cf/d | $.850 | Complete | Dresser |
| Wynnewood, Okla. Kerr-McGee Oil | cat. cracker,<br>poly units<br>gas conc. | 6000 b/d<br>—<br>— | — | Late, 54 | Ref. Eng. Co. |
| Wynewood, Okla. Kerr-McGee Oil | crude unit | 6000 b/d | $4.5 | April, 54 | Koch Eng. Co. |
| Moore Co., Texas Kerr-McGee Oil | natural gasoline | 55 mm cf/d | $.850 | Early, 53 | Dresser |
| Gulf Coast, Texas Koppers | polyethylene plant | — | — | Mid-55 | Koppers Eng. and Constr. Liv. |
| Kalamazoo, Mich. Lakeside Refining | cat. reformer | 1500 b/d | $.2 | — | Staff |
| Ireton, Alta., Leduc Southern Absorption | absorption plant | — | $2.5 | 54 | — |
| Alma, Michigan Leonard Refineries | expand. cracker capacity | 4000 b/d | — | — | Cat. Constr. |
| El Dorado, Ark. Lion Oil Ref. | cat. cracker<br>alkylation | 10,000 b/d<br>1150 b/d | $5. | Fall, 53[1] | Kellogg, Lummus |
| El Dorada, Ark. Lion Oil | cat. cracker unit<br>alkylation plant | 5000 b/d<br>1150 b/d | $5. | Late, 53<br>Late, 53 | Lummus |
| Ft. Chadbourne, Tex. Lone Star Producing | gasoline plant | 30mm cf/d | $3. | Feb., 53 | Gas Plant Constr. |
| Springtown, Texas Lone Star Gas Co. | natural gasoline plant | 45 mm cf/d | $.600 | Fall, 53 | Staff |
| Brownsville, Texas McBride Ref. | cat. reformer add., etc. | 12,500 b/d | $2.5 | Mid-54[1] | — |
| Edinburg, Texas McBride Refining | modernization | 3500 b/d | — | — | — |
| Pt. Brownsville, Tex. McBride Refining | cat. reformer, etc. | 7 mm b/d | $2.5 | Fall, 54[1] | — |
| Edmonton, Canada McColl-Frontenac, Ont. | expansion | — | $10. | Late, 54 | — |
| Edmonton, Alberta McColl-Frontenac | capacity increase | 11,000 b/d | $4. | Early, 55 | — |
| Tyler, Texas McMurrey Refg. | HF alkylation<br>pet. refining<br>platforming unit | 1400 b/d<br>—<br>5000 b/d | —<br>$.7<br>— | Complete<br>—<br>Complete | —<br>—<br>— |

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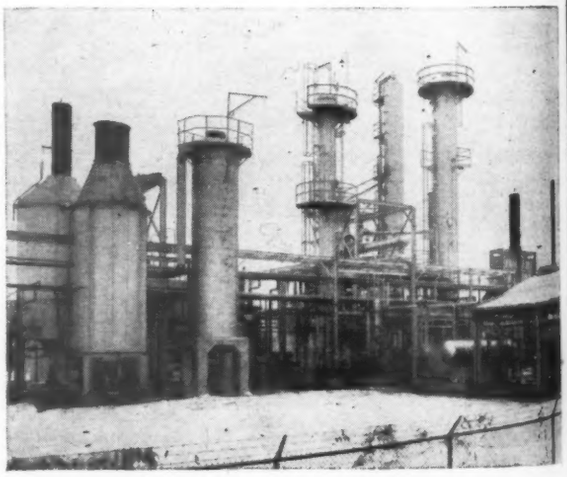

# Results at R.J.'s new Platformer show advantages of

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Throughout the petroleum refining industry, Procon has established an enviable record for getting processing units on stream faster, more efficiently and more economically.

A good example is the 600 B/SD UOP Platforming unit constructed at the Princeton, Ind. refinery of the R. J. Oil and Refining Company, Inc.

One of the reasons why Procon built this unit with maximum speed and efficiency is that it implemented its "off-the-shelf" designs with construction service based on its wide experience gained from previous construction of UOP Platformers.

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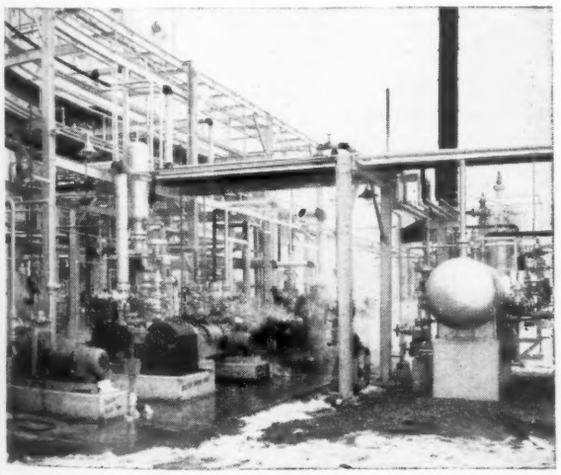
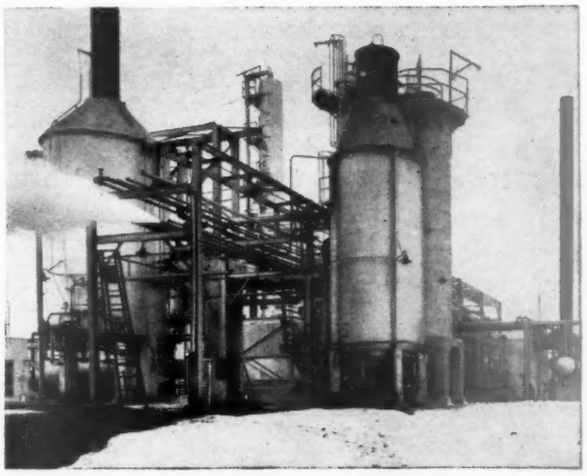
Procon has available complete designs for UOP Platforming units ranging from 600 B/SD to 16,000 B/SD—"off-the-shelf" construction that means vital savings in time and costs.

IT'S PLAIN GOOD SENSE for any refiner to choose Procon when he wants the ultimate in ANY type of process construction.





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## ROSTER OF REFINING, NATURAL GASOLINE, AND PETROCHEMICAL PLANTS — Continued

Started or completed between January 1, 1953 and March 1, 1954

| Location and Company Name | Kind or process | Capacity | Cost, approx. ($ mill.) | Date comp'd[1] or operating[2] | Builder |
|---|---|---|---|---|---|
| Tyler, Texas McMurrey Ref. | crude dist., feed stock prep. | "Doubles capacity" | $2.8 | Late, 54 | Blaw-Knox |
| Brickland, N. Mex. McNutt Refs. | platformer | 600 b/d | — | Oct., 53[2] | Staff |
| | thermal crax and poly. expansion | up 1/3 to ½ | — | Oct., 53[2] | Staff |
| Brickland, N. M. McNutt Oil & Ref. | platformer | 600 b/d | $.3 | 53 | Staff |
| Memphis, Tenn. M. F. A. | cat cracker and aux. | 2200 b/d | $1.7 | March, 53 | Koch |
| Beaumont, Texas Magnolia | TCR | — | — | Mid-54[1] | Lummus |
| Beaumont, Texas Magnolia | therm. cat reforming | 17,000 b/d | $10. | Late, 54 | Lummus |
| Hurricane Creek Field, Beauregard Parish, La., Magnolia | Casinghead gasoline plant | — | — | — | — |
| Midland Co., Texas Magnolia | natural gas and butane | — | $8.3 | — | — |
| Bahia, Brazil Mataripe refinery | lube plant, expansion add. | — / 5000 b/d | — / $12.5 | — / 54 | — / Kellogg |
| Oklahoma City, Okla. Mercury | cat. crk.; poly. | 2500/360 b/d | $3.2 | — | Ref. Eng. |
| | topping; thermal | 5900/1800 b/d | | | |
| Tulsa, Co., Okla. Mid-Continent | aviation gasoline | — | $1.19 | — | — |
| W. Tulsa, Okla. Mid-Continent | cat. reformer | 7500 b/d | $2.5 | June, 54 | Kellogg |
| West Tulsa, Okla. Mid-Continent | debutanizer, cat cracker | 10 mb/d add 5000 b/d | $.536 | Spring, 54 | — |
| Cushing, Okla. Midland Co Op | capacity exp | 4000 b/d | $3. | May, 53 | Ref. Eng. |
| Stettler, Alta. Midland Pet. Pacific | crude refinery | 4000 b/d | $2. | — | Procon |
| Alma, Mich. Mid-West Ref. | gasoline | 1400 b/d | $.348 | June, 53 | — |
| Salt Lake City, Utah Salt Lake Chemical | ammonia plant | 180 t/d | — | Late, 54 | Tears Eng. and H. C. Beck |
| Yazoo City, Miss. Miss. Chemical | enlarge $NH_3$ unit | 60 t/d exp. | $2. | Late 53 | Girdler |
| Bakersfield, Calif. Mohawk Pet. | catformer | 2500 b/d | $.6 | April, 54[1] | Parsons |
| San Antonio, Texas Monarch Ref. | fluid cat. cracker | 4000 b/d | — | — | — |
| | poly. unit | 2500 b/d | $12.5 | Mid- 53 | Koch |
| | alky. unit | 2500 b/d | — | — | — |
| Lincoln Co., Okla. Moran Gasoline | cycling plant | 8½mm cf/d | — | Late, 53[1] | — |
| South Gate, Calif. Nat'l Aluminate | cracking cat. mfg. unit | — | — | Jan., 54 | — |
| McPherson, Kan. Nat'l. Co Op. | coking unit | 10 mb/d | $1.1 | Fall, 53 | Ref. Eng. |
| Tuscola, Ill. Nat'l Petro. | gasoline plant | 450 mg/d | $44. total project | Sept., 53[2] | — |
| Newton, Mass. Nat'l. Research | petro. lab. | — | — | Mid-54 | Griffin |
| Hawkins, Texas Natural Gasoline | plant expansion | 3 mm cf/d | — | June, 53 | Gas Plant |
| St. Paul Park, Minn. N. W. Ref. | topping and cracking unit | 30 mb/d | $2. | Aug., 53 | — |
| Cleveland, Ohio Ohio Standard | crude topping | 7000 b/d | $4.2 | — | — |
| | cracker; | 18 m | | | |
| | poly. | 40 b/d | | | |
| Lovell, Wyo., Ohio Oil | cycloversion cat. crk. | — | — | Nov., 53[2] | Grebe & Doremus |
| Robinson, Ill. Ohio Oil | coking unit | 5000 b/d | — | May, 53 | Lummus |
| | Houdriforming | 8000 b/d | — | Late, 53 | Cat. Constr. |
| Robinson, Ill. Ohio Oil | Houdriforming | 8000 b/d | — | March, 54 | Cat. Constr. |
| | cat. cracker expan. | 18,000 b/d | — | May, 54 | Staff |
| | cat. poly. expan. | 4800 b/d | | May, 54 | Staff |
| | alkylation unit | 1500 b/d | $1.8 | — | Parsons |
| Muskegon, Mich. Old Dutch Ref. | aromatic fac. | 150 b, 370T | $.515 | Under constr. | — |
| Denver, Colo. Oriental Refining | perco cycl. unit | 1500 b/d | — | — | — |
| Puget Sound, Wash. Pacific Oil & Ref. | refinery | 10,000 b/d | — | — | — |
| Pana, Ill. Pana Ref. | platformer modernization | 1600 b/d | $.9 | Mid 53 | Procon |
| Pana, Ill., Pana Ref. | Girbotol unit | — | — | — | Parker |
| El Dorado, Ark. Pan Am So. | Ultraformer | 7200 b/d | $2.9 | July, 54 | Lummus |
| Pedricktown, N. J. Pan American Ref. | refinery, complete | — | — | — | — |
| Texas City, Texas Pan American Ref. | fluid cat., | 30,000 b/d | — | Oct., 53[2] | Lummus |
| | cat. reformer | 21,000 b/d | | | |
| | double alkylation | | | | |
| Texas City, Texas Pan American Ref. | Ultraforming unit | 21,200 b/d | — | Fall, 54 | Kellogg |
| Texas City, Texas Pan American Ref. | refinery expan. | 12,000 b/d | $1.8 | Under constr. | Lummus Texas-Gulf |
| | fluid cat. cracking | 30,000 b/d | | | |
| | poly. unit | 2400b/d | — | — | — |
| York Co., Va. Pan-American Ref. | refinery | 25,000 b/d | — | Late, 55[2] | — |
| Destrehan, La. Pan Am So. | cat. crk., gas. | 12,000 b/d | $6.5 | — | Lummus |
| | alkylation | 2500 b/d | — | — | |
| | fluid hydroformer | 2000 b/d | — | — | Kellogg |
| | coker | 9000 b/d | — | — | Lummus |
| Destrehan, La. Pan Am So. | Fluid Hydroformer | 2500 b/d | — | Jan., 53[2] | Kellogg |
| El Dorado, Ark. Pan Am So. | Hydroformer | — | — | Mid-54[2] | Lummus |
| Wichita Falls, Texas Panhandle Prod. & Ref. | topping unit | 8000 b/d | — | Early, 54 | — |
| Trent, Texas Payne-Johnston-Byars | gasoline plant | 10 mm cf/d | — | Fall, 54[1] | — |
| Oil City, Pa., Pennzoil | crude unit | 9000 b/d | — | Fall, 54 | Kellogg |
| Rouseville, Pa. Pennzoil | expan. two stage distil. | 12,000 b/ d | $1.5 | July, 54 | Kellogg |
| Argentina, P. Peron | fluid cat., whole ref. | 28,300 b/d | — | Late, 53 | Kellogg |
| Chicago, Ill. Petco Corp. | platformer | — | $1. | Fall 54 | Procon |
| Minatitlan, Mexico Pemex Mex. | TCC unit | — | — | 54[1] | Flour |
| Minatitlan, Mexico Pemex Mex. | TCC unit, poly. unit gas concentration | — | — | 55[1] | Fluor |
| Flat Rock, Mich. Petroleum Spec. | cat. cracker | 3000 b/d | $2. | — | — |
| Alvin, Tex., Phillips | natural gas expan. | 3570 b/d | — | — | Tellepsen |
| Big Spring, Texas Phillips Chemical | p-xylene unit | — | — | Jan., 54[2] | — |
| Borger, Tex., Phillips | alky. expan. | — | $15.5 | 53 | Phillips |
| Borger, Tex., Phillips | central fract. ext. | — | — | 53 | Phillips |
| Brazoria Co., Texas Phillips Pet. | natural gasoline | 100 mm cf/d | — | 53 | Phillips |
| Ector Co., Texas Phillips Pet. | natural gasoline | 125 mm cf/d | $5.4 | Early, 53 | Phillips |
| Eunice, N. M. Phillips Chemical | sulfur extrac. | 100 tons | $1.5 | — | — |
| Gray Co., Tex., Phillips | natural gasoline | — | $.409 | — | — |
| Great Falls, Mont. Phillips | refining | — | $3. | — | — |
| Houston, Tex., Phillips | petrochemicals | 400 tons | $38. | 2nd Qtr. 53 | Fish Eng. |
| Lea City, N. M. Phillips Pet. | natural gasoline | — | $27. | — | — |
| Midland, Texas Phillips Pet. | natural gas. plant | 100 mm cf/d | — | 53 | Phillips |
| | natural gas. plant | 60 mmcf/d | $212. | Complete | Phillips |
| Moore Co., Texas Phillips Pet. | natural gasoline | — | $1. | — | — |
| Sweeny, Tex., Phillips Phillips | UOP platformer | 16,000 b/d | — | Late, 54[1] | Procon |
| Upton Co., Texas Phillips Pet. | natural gas. plant | 60 m cf/d | — | 53 | Phillips |
| Wood's Cross, Utah Phillips Pet. | refinery expansion | 5000 to 12,000 b/d | $10. | 54 | — |
| Corpus Christi, Tex. Pontiac Ref. | av. gas expan. | — | $2. | — | — |
| Ft. Worth, Texas Premier Pet. | refinery expan. | — | $3.6 | — | — |
| Ft. Worth, Texas Premier Ref. | fluid cat cracker | 2800 b/d | $2.1 | March, 54 | Ref. Eng. |
| Longview, Texas Premier Pet. | cat. poly. plant | — | — | — | — |
| Florence, Ariz. Proven Oil & Ref. | refinery | 15,000 b/d | $18.3 | 55 | — |
| Heath, Ohio Pure Oil | cat. reformer (Sinclair-Baker) | 3000 b/d | — | 2nd Qtr. 54 | Kellogg |
| Smiths Bluff, Texas Pure Oil | basic refining | — | $10.8 | 53 | — |
| | alkylate unit | 1901 b/d | $.390 | 53 | — |
| | cat. poly. | 135 b/d | — | 53 | Kellogg |
| | expan. alkyl. | 1900 b/d | $.390 | 53 | Kellogg |
| | modernization | — | $11. | Spring, 53 | Kellogg |
| | orthoflow crk. | 15,000 b/d | — | — | — |
| | power expan. | — | — | Early, 53 | Tellepsen |
| | feed prep-vac. flash | 20,000 b/d | — | — | Kellogg |
| Toledo, Ohio, Pure Oil | steam boilers | — | — | Late, 53 | Catalytic Constr. |
| Toledo, Ohio Pure Oil | alkylation unit (sulfuric acid) | — | $2.5 | — | — |
| | modernization | 30,000b/d | — | Spring, 53 | Kellogg |
| | orthoflow cat. | 15,000b/d | — | Spring, 53 | Kellogg |
| Bradford, Pa. Quaker State | platformer | 1500 b/d | — | Spring, 54 | Procon |
| Emlenton, Pa. Quaker State | platformer | 850 b/d | — | Late, 54 | Procon |
| St. Mary's, W. Va. Quaker State | platformer | 850 b/d | — | Late, 54 | Procon |

## ROSTER OF REFINING, NATURAL GASOLINE, AND PETROCHEMICAL PLANTS — Continued

### Started or completed between January 1, 1953 and March 1, 1954

| Location and Company Name | Kind or process | Capacity | Cost, approx. ($ mill.) | Date comp'd[1] or operating[2] | Builder |
|---|---|---|---|---|---|
| Big Spring, Texas Reef Fields Gas. | gasoline plant | 34 mm cf/d | — | Early, 53 | Delta |
| Howard Co., Texas Reef Fields Gas. | gasoline plant | 250mg/d | — | Early, 53 | — |
| Texas City, Texas Republic Oil | platformer | 5500 b/d<br>6500 b/d | $7. | Jan., 54[1] | Procon |
| Texas City, Texas Republic Oil | platforming unit | 6500 b/d | $7. | Spring,53 | Procon |
| Bakersfield, Calif. Richfield Oil | gasoline plant exp. | add 25 mm cf/d | — | Mid-54[1] | — |
| Los Angles, Calif. Richfield Oil | ref. expansion | 20,000 b/d | $40. | Aug., 54 | Fluor |
| Watson, Calif. Richfield Oil | expansion; cat. cracker; aromatics | 20,000 b/d | $43. | 54 | Fluor |
| Ft. William, Ont. Riverlake Oil | refinery | 4000 b/d | $1. | Early, 54 | — |
| Mt. Pleasant, Mich. Roosevelt O & R | platformer | 1750 b/d | — | — | Procon |
| Santa Fe Springs, Cal. Rothschild Oil | cat. cracker | 6000 b/d | $2. | — | Braun |
| Santa Fe Spr. Calif. Rothschild Oil | platformer | 1000 b/d | — | Nov., 53[2] | Staff |
| Coleville, Sask. Canada Ref. Oper. & Roy. | crude topping unit | 5000 b/d | — | April, 53 | — |
| Kamloops, B. C. Royalite Oil | refinery | 5600 b/d | — | Nov., 54 | — |
| Shallow Water, Kans. Shallow Water Ref. | cat. cracker | 3000 /b/d | — | Late, 53 | — |
| Sunray, Texas Shamrock O & G | aviation alky. | 16,000 b/d | $2. | March, 53 | Gas Plt. Constr. |
| Anacortes, Wash. Shell Oil | crude unit, cat. cracker, platformer | 50,000 b/d | — | 55[1] | — |
| Anacortes, Wash. Shell Oil | refinery | 50,000 b/d | $75. | End, 55 | Bechtel |
| Deer Park, Tex., Shell | pet. ref. | — | $.3 | — | — |
| Elk City, Okla. Shell Oil | expansion, Elk City plant | 75mmcf/d | — | Spring, 54 | Fluor |
| Geelong, Australia Refinery (Shell) | cat. cracker<br>refinery | 15m b/d<br>25mb/d | —<br>— | Late, 54<br>Late, 54 | —<br>— |
| Houston, Texas Shell Oil | platforming unit | 16mb/d | $12. | — | — |
| Jumping Pound, Can. Shell Oil | gas processing | 45mm cf/d | — | Fall, 54[1] | Ref. Eng. Co. Canada |
| Martinez, Cal., Shell | platformer unit | 4500 b/d | $1.7 | June, 54 | Braun |
| Norco, La. Shell Chemical | glycerine, epon resins | 25mm lb/yr | — | Late, 54 | Fluor |
| Norco, La. Shell Oil | expansion | 25m b/d | $41. | Late, 54 | Bechtel, Procon, Foster Wheeler, McKee |
| Stanlow, England Shell Pet. | platformer unit | — | $10. | Early, 54 | — |
| Vancouver, B. C. Shell of Canada | refinery expan. | 15m b/d | $10. | Late, 53 | Fluor |
| Ventura, Calif. Shell Oil | gasoline plant ext. | — | $1. | Sept., 53 | Fluor |
| Ventura, Calif., Shell | ammonia plant | — | — | Early, 54 | Kellogg |
| Wilmington, Calif. Shell Oil | distillation tower | 50m b/d | $7. | Late 53 | Bechtel |
| Wood River, Ill. Shell Oil | offsite fac.<br>expan. & improvem't<br>platforming unit | —<br>50m b/d<br>16m b/d | —<br>$42.5<br>— | Late, 54<br>Late, 54<br>Feb., 54 | Fluor<br>Foster Wheeler, Fluor & McKee<br>Procon |
| Texas City, Texas Sid Richardson | refinery alterations | 30m b/d | — | — | Staff |
| Carter Co., Okla. Signal | natural gasoline plant | 40mm cf/d | — | May, 54[1] | Staff |
| Carter Co., Okla. Signal | cycling plant | 40mm cf/d | — | Spring, 54[1] | Staff |
| Los Angeles, Signal Oil and Gas | butanes-iso-butane | — | $.5 | — | — |
| Tioga, N. D. Signal Oil and Gas | Gasoline plant | 65mm cf/d<br>200m g/d | $15. | Early, 54 | Pritchard, Brown and Root |
| East Chicago, Ind. Sinclair Ref. | gasoline frac. | 20m b/d | $1.3 | Fall, 54 | Graver |
| E. Chicago, Ind. Sinclair Ref. | barrel house fac.<br>power plt. addi. | —<br>— | $2.7<br>$.57 | Mid-54<br>Mid-54 | —<br>— |
| Hartford, Ill., Sinclair | asphalt fac. | — | $.6 | Spring, 54 | Staff |
| Hartford, Ill. Sinclair Ref. | gasoline fac.<br>crude expan.<br>sulfur extrac. | —<br>37m b/d<br>10m b/d | $34.4<br>—<br>$3.4 | —<br>—<br>Mar., 53 | —<br>—<br>Badger Div. |
| Houston, Texas Sinclair Ref. | crude dist and vacuum units<br>cat. crk. and gas plt.<br>barium sulfonate | 25m b/d<br>40m b/d<br>— | $33.6<br><br>$.145 | Complete<br><br>53 | Fluor-Braun<br><br>Braun |
| Marcus Hook, Pa. Sinclair Chem. | p-xylene unit | 10mm lb/yr | — | 55 | — |
| Marcus Hook, Pa. Sinclair Ref. | cat. reforming | 16m b/d | $14. | Mid-54 | Braun |
| Sinclair, Wyo. Sinclair Ref. | plant expan. | add 6000 b/d | — | Mid-53 | — |
| Wellsville, N. Y. Sinclair Ref. | propane deres. | 700 b/d | $1. | Mar., 53 | Fluor |

| Location and Company Name | Kind or process | Capacity | Cost, approx. ($ mill.) | Date comp'd[1] or operating[2] | Builder |
|---|---|---|---|---|---|
| El Dorado, Kan. Skelly Oil | platformer unit | 7500 b/d | — | Late, 54 | Staff |
| Eunice, N. M., Skelly | gasoline expansion | 20mm cf/d | — | April, 54 | J. E. Carlson |
| Augusta, Kan. Socony-Vacuum | cat. reforming | — | — | Nov., 54 | Bechtel |
| Augusta, Kans. Socony-Vacuum | TCR | — | $3. | Early, 54 | Bechtel |
| Beaumont, Texas Socony-Vacuum | TCR | — | — | — | — |
| E. Chicago, Ind. Socony-Vacuum | av. gas. fac. | — | $4. | — | — |
| E. St. Louis, Ill. Socony-Vacuum | alky. expansion<br>cat. poly. | 775 b/d<br>— | $.260<br>— | Sept., 54<br>Sept., 54 | Socony-Vacuum<br>Lummus |
| E. St. Louis, Mo. Socony-Vacuum | TCC unit | 15m b/d | — | Sept., 54 | Lummus |
| Manderson, Wyo. Socony-Vacuum | gasoline plant | 15mm cf/d | $15. | Late, 54 | R. M. Parsons |
| Paulsboro, N. J. Socony-Vacuum | bead catalyst | — | $2.3 | Complete | Bechtel |
| Torrance, Calif. Socony-Vacuum | TCR | — | — | — | — |
| Trenton, Mich. Socony-Vacuum | cat. poly. | — | — | Mar., 54 | Badger |
| Corpus Christi, Tex. Southwestern Oil and Refining | crude topping<br>cat. crk.,<br>poly. | 15m b/d<br>5m/<br>200m b/d | —<br>$5.5 | Complete<br>Mid-53 | Ref. Eng. |
| Pledger Field, Tex. Southern Production | gaso. absorption plant | 190mm cf/d | $5.8 | Complete | Stearns-Roger |
| Casper, Wyo. Standard Oil, Ind. | alkylation unit | 700 b/d | — | Mid-54 | Kellogg |
| Casper, Wyo. Standard Oil, Ind. | Ultraformer | 3750 b/d | — | Early, 55 | Lummus |
| Casper, Wyo. Standard Oil, Ind. | alkylation unit | 575 b/d | — | Mid-54 | Graver |
| Cleveland, Ohio Standard, Ohio | naphtha treater | — | $.3 | Late 53 | McKee |
| Cleveland, Ohio Standard, Ohio | alkylation feed | — | $6.7 | — | — |
| El Segundo, Calif. Standard, Calif. | p-xylene unit | — | — | — | — |
| El Segundo, Calif. Standard, Calif. | cat. reformer | 20m b/d | — | — | — |
| El Segundo, Calif. Standard, Calif. | cat. cracker,<br>offsite fac., alky.<br>residuum stripper | 36m b/d<br><br>52m b/d | $20. | Aug., 54<br><br>Mar., 54 | Fluor<br>Macco<br>Kellogg |
| El Segundo, Calif. S. O. Calif. | platformer unit | — | — | Late, 54 | — |
| El Segundo, Calif. Standard | cat cracker | 36m b/d | $20. | 54 | — |
| El Segundo, Calif. Standard Calif. | cat. cracker<br>resid. stripper | 40m b/d<br>52m b/d | — | — | — |
| Grand Forks, N. D. Standard N. D. | refinery | 2-25m b/d | — | — | — |
| Lima, Ohio Standard Ohio | crude coking<br>cat reforming | —<br>3m b/d | $2.4<br>$8.5 | —<br>Mid-54 | —<br>— |
| Lima, Ohio Standard Ohio | LPG- cavity storage | 60m b/d | $.45 | Mid-54[1] | Staff |
| Lima, Ohio, S. O. Ohio | platformer | 12m b/d | $8. | July, 54 | Procon |
| Lima, Ohio Standard Ohio | tankage | — | $8. | Late 53 | McKee |
| Lima, Ohio Standard Ohio | platformer | 12m b/d | $7.5 | Early, 54 | Procon |
| Mandan, N. D. Standard Ind. | complete crude refinery | 30m b/d | — | Nov., 54 | Lummus |
| Neodesha, Kans. Standard Ind. | cat. cracker; alky. | 9300 b/d | $10. | — | — |
| Richmond, Calif. Standard Calif. | cat. cracker | 36m b/d | — | — | — |
| Richmond, Calif. Standard Calif. | platformer unit | — | — | Late, 54 | — |
| Richmond, Calif. Standard Calif. | cat. reformer | 20m b/d | $20. | July, 55 | — |
| Snyder, Texas Standard Texas | natural gasoline | 30mm cf/d | $2.5 | May, 53 | Staff |
| Sugar Creek, Mo. Standard Ind. | crude expan.<br>olefin concen. | 30m b/d<br>320 b/d | $21.<br>$.142 | —<br>— | —<br>— |
| Toledo, Ohio Standard Ohio | alkylation unit | — | $3. | Mid-53 | McKee |
| Vancouver, B. C. Standard B. C. | model 4<br>fluid cat. and ref. | —<br>11m b/d | —<br>$10. | Oct., 54[1]<br>Oct., 54[1] | —<br>— |
| Whiting, Ind. Standard Ind. | Fluid Hydroformer | 27m b/d | — | Early, 55 | Kellogg |
| Whiting, Ind. Standard Ind. | p-xylene unit | 14mm lb/yr | — | Early, 54 | Badger |
| Whiting, Ind. Standard Ind. | Hydroformer | 24mm b/d | — | Late 54 | — |
| Whiting, Ind. Standard Ind. | Hydroformer | 30m b/d<br>(24m b/d Jan., 53) | — | End, 54[1] | Kellogg |
| Wood River, Ill Standard Ind. | Fluid Hydroformer<br>additives plt.<br>alcohols prod. | 9000 b/d<br>9000 g/d<br>30m lb | —<br>—<br>$2.6 | 54<br>Early, 53<br>Mid 53 | —<br>Staff<br>— |
| Wood River, Ill. Standard Ind. | Ultraformer | 9000 b/d | — | Late 54 | — |

## ROSTER OF REFINING, NATURAL GASOLINE, AND PETROCHEMICAL PLANTS — Continued

Started or completed between January 1, 1953 and March 1, 1954

| Location and Company*Name | Kind or process | Capacity | Cost, approx. ($ mill.) | Date comp'd[1] or operating[2] | Builder |
|---|---|---|---|---|---|
| Garfield Co., Okla. Sterling | gasoline ext. plant | 16 m g/d | — | March, 54 | — |
| Oklahoma Co., Okla. Sterling | gasoline ext. plant | — | — | — | — |
| Andrews Co., Texas Stanolind | natural gasoline | 11 mm cf/d | — | Jan., 54 | Hudson |
| Odessa, Texas Stanolind | sulfur rec. plant | 17.7 lt | — | Early, 53 | Girdler |
| Sundown, Texas Stanolind | gas plant | 23 mm cf/d | — | Jan., 53 | Blaw-Knox |
| Sarnia, Ont. Sun Oil | refinery | 10 m b/d | $10. | March, 53 | Cat. Constr. |
| Sarnia, Ontario Sun Oil | Houdriflow cat cracker | 11,500 b/d | — | Spring, 54 | — |
| Toledo, Ohio Sun Oil | catalytic reforming unit (platform unit) | 10 m b/d | $7.2 | Spring, 54 | Procon-Cat. |
| Duncan, Okla. Sunray Oil | platformer | 5000 b/d | $1.3 | Aug,. 54 | — |
| Duncan, Okla. Sunray Oil | platformer | 5000 b/d | — | Late, 54 | Design-Mech. Design, Constr.-Refinery Eng. |
| Ducan, Okla. Sunray Oil | alkylation revamp | 1500 b/d | $1.7 | Sept., 54[2] | Staff |
| Ducan, Okla. Sunray (Ucan Prod.) | delayed coker | 9000 b/d | — | Late, 54[1] | Lummus |
| Ducan, Okla. Sunray Oil | coking unit | 9000 b/d | $4. | Oct., 54 | Lummus |
| Ducan, Okla. Sunray Oil | alkylation fac. | 2400 b/d | $1.7 | Spring, 53 | Ref. Eng. |
| Santa Maria, Calif. Sunray Oil | reconstruction | 5000 b/d | — | — | Procon |
| Sarepta, La. Sunray Oil | cycling and gas. plant | 12 mm cf/d | $1.3 | Late, 54 | Born Eng. |
| Snyder, Texas Sunray Oil | LPG recovery | 100 m g/d | — | Mid-54 | — |
| Snyder, Texas Sunray Oil | gasoline plt. ext. | — | $1.5 | Late, 54 | Fluor |
| Corpus Christi, Tex. Suntide Ref. | new refinery | 30 m b/d | — | Spring, 54 | — |
| Corpus Christi, Tex. Suntide Ref. | new refinery | — | — | Fall, 53[2] | — |
| Corpus Christi, Tex. Suntide Ref. | crude oil ref.<br>increase alky. fac. | 30 m b/d<br>50 m b/d | $15.<br>$11.4 | Complete | Lummus |
| Corpus Christi, Tex. Suntide Ref. | cat. cracker | 28 m b/d | $16. | Mid-53 | Lummus |
| Corpus Christi, Tex. Taylor O & G | platformer | 5000 b/d | — | Sept., 54[2] | UOP |
| Corpus Christi, Tex. Taylor O & G | platformer | 5000 b/d | — | Sept., 54[2] | Staff |
| Corpus Christi, Tex. Taylor O & G | platformer | 5000 b/d | — | Nov., 53[2] | Procon |
| Corpus Christi, Tex. Taylor O & G | platformer unit | 5000 b/d | — | July, 53 | Staff |
| Agua Dulce, Texas Tennessee Prod. | natural gasoline plant | 100 mm cf/d | — | Late, 53 | Olsen & Co. |
| Edmonton, Atla. Texaco Expl. | absorption unit | — | $6.2 | 54 | — |
| Texas City, Texas Texas City Ref. | Houdriflow cat. cracker | 19 m b/d | — | Nov., 53[1] | Houdry |
| Texas City, Texas Texas City Ref. | cat. cracker<br>avia-alkylate | 17,500 b/d<br>— | $2.4<br>$2.5 | April, 53<br>— | Kaiser<br>— |
| Amarillo, Texas Texas | av. gasoline fac. | 47 m b/d | $20.7 | Late, 54 | — |
| Amarillo, Texas Texaco | refinery expansion | 8500 b/d | — | 54 | Kellogg |
| Amarillo, Texas Texaco | fluid cat.<br>delayed coking<br>alkylation<br>cat. poly. | 6000 b/d<br>3600 b/d<br>—<br>470 b/d | Late, 54 | — | Kellogg |
| Amarillo, Texas Texaco | expan. & mod., cat. cat. cracker, atmos. crude, pipe still, delayed coker, alky. unit, cat. poly., treating and LPG handling fac. | 7500 b/d | $20.5 | End, 54 | Kellogg, etc. |
| El Paso, Texas Texaco | expan. and mod. atmos. crude pipe still, cat. cracker, delayed coker, cat. poly., treating and LPG handling fac. | 5400 b/d | — | End, 54 | Foster Wheeler, etc. |
| El Paso, Texas Texaco | cat. poly.<br>crude dist.<br>cat. cracker<br>cat. reformer | —<br>10 m b/d<br>—<br>— | — | Late, 54 | — |
| El Paso, Texas Texaco | expan. mod. | 5000 b/d | — | Late, 54 | — |
| Honor Rancho Field, Calif. Texaco | gasoline plant | 18 mm cf/d | — | April, 54[1] | Offco Constr. |
| Lawrenceville, Ill. Texaco | cat. reformer<br>alkylation unit | 13,631 b/d<br>2253 b/d | —<br>— | Late, 55<br>Late, 55 | —<br>— |
| Lockport, Ill. Texaco | lube oil plant<br>crude expan. | 3485 b/d<br>25 m b/d | $17.6<br>$15. | —<br>— | —<br>— |
| Paradis, La. Texaco | gasoline plant | 115 mm cf/d | — | — | Olsen |
| Port Arthur, Texas Texaco | catalytic reformer | 20 m b/d | $1.3 | Mid-54 | Procon et al |
| Port Arthur, Texas Texaco | addition cracked naphtha stabilization fac. | 25 m b/d | — | Complete | Caruth-Dickerson etc. |
| Port Arthur, Texas Texaco | expansion | 20 m b/d | — | 53 | — |
| Sunburst, Mont. Texaco | cat. poly. | 37 m b/d | — | Late, 53[1] | Staff |
| Westville, N. J. Texaco | platformer | 10 m b/d | $6.+ | Mid-54 | — |
| Westville, N. J. Texaco | alkylation unit | 2000 b/d | — | Mid-54[1] | Staff and James P. O'Donnell |
| Westville, N. J. Texaco | cat. reforming<br>alkylation fac. | 12 m b/d<br>1850 b/d | —<br>— | Late, 54<br>Late, 54 | —<br>— |
| Tulsa, Okla. Texas Nat. Gas. | gasoline, propane, butane | — | — | — | — |
| Avon, Calif. Tide Water | hydrocarbon platformer | — | $2.5 | Late, 54 | Braun |
| E. Bernard, Texas Tide Water | natural gas. | — | $.65 | Jan., 53 | Fish |
| Drumright, Okla. Tide Water | crude topping; vacuum | 15 m b/d<br>6000 b/d | — | Spring 53 | Ref. Eng. |
| Batman, Turkey Turkish Ref. | complete refinery | 6250 b/d | $8. | Late, 54[1] | Parsons |
| Cut Bank, Mont. Union Calif. | catalytic reformer | 600 b/d | $.6 | Late, 54 | Parsons |
| Los Angeles, Calif. Union | crude topping<br>alkylate fac. | 40 m b/d<br>250 b/d | $6.<br>$.135 | Complete<br>— | Fluor<br>— |
| Los Angles, Calif. Union Calif. | TCC revision | — | $1.7 | Complete | McKee |
| Oleum, Calif. Union | gasoline and expan. | — | $.84 | — | — |
| Oleum, Calif. Union | unifiner unit | 15,750 b/d | — | Dec., 54[1] | Braun-Bechtel |
| Oleum, Calif. Union | platformer | 14,500 b/d | $5.75 | Nov., 54[1] | Bechtel and Braun |
| San Louis Obispo, Cal. Union | coking | — | — | Early, 55 | — |
| Santa Maria, Calif. Union | coking plant | — | — | Projected | — |
| Wilmington, Calif. Union | crude expan. | 40 m b/d | $27. | Complete | Braun |
| Wilmington, Calif. Union | cat. cracker<br>av-gas | 28,500 b/d<br>— | $4.5<br>$.135 | Complete<br>— | McKee<br>— |
| Timpson, Texas United Chemical | ammonia; urea units | — | $18. | Late, 55 | Foster Wheeler |
| Warren Pa. United Ref. | lab. | Under Construction | | | |
| Warren, Pa. United Ref. | catformer | 2500 b/d | $1. | Mid-53 | Blaw-Knox |
| Warren, Pa. United Ref. | lab. | — | — | Under const. | — |
| Mooringsport, La. Universal Oil Products | synthetic cat. mfg. | — | — | — | — |
| Salt Lake City, Utah Utah Oil | expansion | — | $1. | Complete | CB & I |
| McCook, Ill. Univ. Oil | platformer cat. fac. | — | — | Mid-54[1] | Procon |
| Potwin, Kans. Vickers Pet. | crude expan.<br>TCC | 10 m b/d<br>— | —<br>— | Complete<br>Complete | Koch<br>Sweco |
| Wainwright, Alberta Wainwright Ref. | dehydrating and desalting equip. | 650 b/d | $.30 | — | Petreco |
| Wainwright, Atla. Wainwright Refs. | plant expansion | 300 to 600 b/d | — | — | — |
| Antioch & Lindsay Warren Pet. | natural gaso. plant | — | $2.4 | — | — |
| Antioch, Okla. Warren Pet. | natural gaso. plant | 18 mm cf | $.654 | Complete | Dresser |
| Lea Co., N. M. Warren Pet. | natural gaso. plt. | 22 mm cf/d | — | Feb., 54 | Fluor |
| Lindsay, Okla. Warren Pet | natural gaso. plt. | — | — | 54 | — |
| Lovington, N. M. Warren Pet. | gasoline plant | 76 m g/d | — | Early, 54 | Fluor |
| Maysville, Okla. Warren Pet. | natural gaso. plt.<br>natural gaso. plt. | —<br>— | —<br>— | 54<br>54 | —<br>— |
| Maysville, Okla. Warren Pet. | expansion | 22 mm cf/d | — | Mar., 53 | Dresser |
| Monument, N. M. Warren Pet. | expansion | 23 mm cf/d | — | Complete | Dresser |
| Rangely, Colo. Wesco Ref. | thermal cracker | 1250 b/d | — | Nov. 53 | — |
| Salt Lake City Western States | topping; cracker | 3 m-22 m b/d | $1.1 | — | — |
| Augusta, Kans. White Eagle | therm cat. reform | — | — | — | — |
| Wickett, Texas Wickett Ref. | thermal cracker | 2000 b/d | — | — | — |
| Williston, No. Dak. Williston Basin Ref | refinery | 1500 b/d | $.425 | — | Koch |
| Calumet, Ill. Wood River Oil | crude topping crk.<br>poly. | 15 m b/d<br>6800/600 b/d | $1.<br>$1. | —<br>— | —<br>— |

**1. Leaves no deposits**

Being ashless, Du Pont Fuel Oil Additive No. 2 leaves no combustion chamber deposits to cause operating difficulties.

**2. Gives added flexibility**

To help you gain added flexibility and capacity in diesel fuel production, Fuel Oil Additive No. 2 enables you to blend cat-cracked and straight-run stocks, without sacrificing stability in the blend.

**3. Upgrades heavy oils**

This additive can help you upgrade your heavy distillate fuel oils because it allows a certain amount of these heavy oils to be blended in the diesel fuel without affecting filterability.

**4. Prevents clogging**

Du Pont Fuel Oil Additive No. 2 not only retards the formation of insoluble residues, but also reduces the particle size of those insoluble residues that are formed and thus reduces clogging of diesel filter screens. Highly concentrated, Fuel Oil Additive No. 2 will produce desired results at the lowest possible cost.

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Free samples and more detailed information on Fuel Oil Additive No. 2 are available from any Du Pont Petroleum Chemicals Division representative or regional office.

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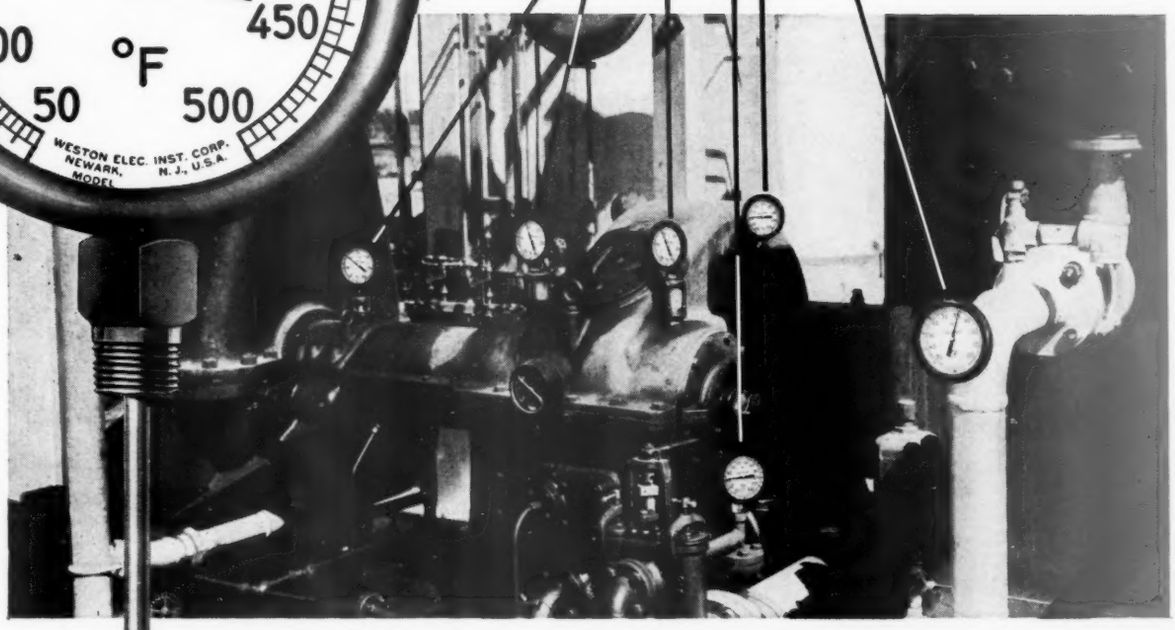
## ROSTER OF REFINING, NATURAL GASOLINE, AND PETROCHEMICAL PLANTS — Continued

Started or completed between January 1, 1953 and March 1, 1954

| Location and Company Name | Kind or process | Capacity | Cost, approx. ($ mill.) | Date comp'd[1] or operating[2] | Builder |
|---|---|---|---|---|---|
| **Petrochemical Plants.** | | | | | |
| Frankford, Pa. Allied Chem. & Dye | phenol-cumene | 23.9 mm lb/yr | — | — | — |
| Philadelphia, Pa. Allied Chem. & Dye | phthalic anhydride | 100 mm lb by June, 53 | — | Early, 54 | — |
| Chicago-Calumet, Ill. Allied Chem. & Dye | phthalic anhydride | 2.5 mm lb/yr | $5. | June, 53 | — |
| Orange, Texas ..... Allied Chem. & Dye (Nitrogenen Div.) | ethylene oxide, ethylene, diethylene triethylene glycol | — | $5. | Early, 54 | Scientific Design |
| Moundsville, W. Va. Allied Chem. & Dye (Solvay Div.) | chlorinated methane products | — | $2. | Mid-54 | — |
| Tonawanda, N. Y. Allied Chem. & Dye (Solvay Div.) | poly. products | 20 mm lb/yr | $10. | Jan., 54 | Lummus |
| New Orleans, La. American Cyanamid | anhydrous ammonia, acetylene, hydrocyanic acid & derivatives; acrylonitrile, ammonium sulfate | 300 t/d | $50. | — | — |
| Philadelphia, Pa. Atlantic Ref. | ammonia | 100 t /d | — | Spring, 54 | — |
| Texas City, Texas Bakelite (Union Carbide) | polyethylene | 60 mm lb/yr | — | Dec., 54 | — |
| Torrance, Calif. Bakelite (Union Carbide) | polyethylene | over 60 mm lb/yr | — | Early, 55 | — |
| Seadrift, Texas Bakelite | polyethylene | over 60 mm lb/yr | — | Mid-54 | — |
| Brea, Calif. Brea Chemicals | ammonia | 150 t/d | $13. | Mar., 54 | — |
| Institute, W. Va. Carbide & Carbon | synthetic ethyl alcohol | 10mm g/ yr | — | Mid-53 | — |
| Pampa, Texas Celanese | vinyl acetate | 30 mm lb/yr | — | July, 53 | — |
| Pampa, Texas Celanese | acetic anhydride | 1.8 mm lb/wk | — | Jan., 53 | — |
| Chipman Chemical | insecticides, weed-killers, fungicides | — | — | Spring, 54 | — |
| Kimberton, Pa. Ciba | ethoxylene resin | 3 to 6 mm lb/yr | — | — | — |
| Natrium, W. Va. Columbia So. Chem. | ammonia | 100 t/d | — | Late, 54 | Nitrogen Eng. |
| Sterlington, La. Commercial Solvents | ammonia-methanol | 15 mm g/yr 200 t/d | $20. | Oct., 53 | Kellogg |
| Agnew, Calif. Commercial Solvents | pentaerythritol | 500 m lb/yr | — | Dec., 53 | — |
| Sterlington, La. Commercial Solvents | nitroparaffin expan. | 5-fold exp. 2 to 10 mm lb/yr | $5. | Late, 55 | — |
| Peoria, Ill. Commercial Solvents | nitroparaffin expan. | 5-fold exp. 2 to 10 mm lb/yr | $5. | — | — |
| Pasadena, Texas Crown Central Pet. | aromatics (houdriformer) | 5000 b/d | $1. | Oct., 54 | Blaw-Knox |
| Louisville, Ky. Devoe & Reynolds | epichlorhydrin | Increasing | — | Mid-53 | — |
| Midland, Mich. Dow Chemical | phenol | 210 mm lb/yr | — | — | — |
| Freeport, Texas Dow Chemical | ammonia | 200 t/d | — | Early, 55 | Austin |
| Midland, Mich. Dow Chemical | vinyltoluene | — | — | Dec. ,53 | — |
| Parlin, N. J. Du Pont | polyester film base | — | | | |
| Circleville, Ohio Du Pont | Mylar | | $10. | Mid-54 | — |
| Tonawanda, N. Y. Durez | phenol | 25 mm lb/yr | — | Nov., 53 | — |
| Baton Rouge, La. Esso Standard | ethyl alcohol | 20 mm g/yr | — | Feb., 54 | — |
| Calvert City, Ky. Goodrich | acrylonitrile | — | $8.5 | Early, 55 | — |
| Calvert City, Ky. Goodrich | vinyl chloride monomer | — | $6. | Late ,53 | — |
| Akron, Ohio Goodyear Tire & Rubber | syn. rubber resin | — | $1.5 | Early, 54 | — |
| Niagra Falls, N. Y. Goodyear Tire | vinyl plastic resins | — | $4. | Early, 54 | — |
| Memphis, Tenn. Grace, W. R. | synthesis gas from NG; ammonia-urea for plastics & glue, fertilizer & animal feed | ammonia: 250 t/d of which 125 t will go into urea | $19. | Fall, 54 | — |
| Corpus Christi, Tex. Great Southern Chem. | benzene-toluene-xylene | 10 m b/d | $5.8 | Fall, 53 | Procon, Fluor |
| Port Arthur, Texas Gulf Oil | ethylene | 2.5 billion cf/yr | — | Mar., 53 | — |
| | ethylene | 3 billion cf/yr | — | Spring, 55 | — |
| Port Arthur, Texas Gulf Oil | platforming plant (world's largest) | 29 m b/d | — | Spring, 54 (complete) 1st qr. 55 | Badger Div. |
| St. Landry Parish, La. Gulf Ref. | | 10 mm bbl butane 11 mm b propane 6.5 mm b cond. | $10. | July, 54 | — |
| Gibbstown, N. J. Hercules Powder | hydrocarbon: phenol, acetone, paracresol cumene alcohol | — | $8. | Early, 54 | — |
| Burlington, N. J. Hercules Powder | dimethyl terephthalate | 12 mm lb/yr | $4. | June, 55 | — |
| Paulsboro, N. J. Hercules Powder | phenol | 26 mm lb/yr | $8.5 | July, 54 | — |
| Mansfield, Mass. Hercules Powder | pentaerythritol | 6 mm exp lb/yr | Fall, 53 | — | — |
| Texas City Heyden-Monsanto | meth. from acety. by-product gas | 25 mm g/yr | — | Late, 53 | — |
| Tacoma, Wash. Hooker Electrochem. | ammonia | 60 t/d | $5. | Mid 54 | — |
| Baytown, Texas Humble | para-xylene production and separation | 25 mm lb/yr | — | Oct., 53 | — |
| New Haven, Conn. Humphrey-Wilkinson | olefins, alcohols, ethers, mercaptans, chlorides, alkyenyl succinic anhydrides | double mfg. capacity | — | Dec., 53 | — |
| Luling, La. Lion Oil | ammonia | 300 t/d | — | 54 | — |
| Morgentown, W. Va. Mathieson Chem. | hexamethylene-tetramine | — | — | — | — |
| Salt Lake City Mill Creek Chem. | anhydrous ammonia | 180 t/d 30 t dry ice | — | — | Tear Eng., Beck |
| Texas City, Texas Monsanto | polyethylene | 66 mm lb; 50% increase in 57 | — | Late, 54 | Farnsworth-Chambers |
| Springfield, Mass. Monsanto | high impact styrene | — | — | April, 54 | — |
| Texas City, Texas Monsanto | acetylene | — | — | Jan., 53 | — |
| Monsanto, Ill. | | 30m | | | |
| Avon, Calif. Monsanto (twin units) | phenol | lb/yr | — | Dec., 53 | — |
| Avon, Calif. Monsanto | phenol | 20 m lb/yr | $4. | Operating | — |
| Tuscola, Ill. National Petro-Chem. | synthetic ethanol | 128 m g/d | $.50 | Oct., 53 | — |
| | ethane | 10 m cf | | | |
| | propane | 330 m g | | | |
| | butane | 70 m g | | | |
| | gasoline | 19 m g | | | |
| | ethylene | 200 mm lb/yr | | | |
| | hydrogen | 490 m cf | | | |
| | light hydrocarbons | 2800 g | | | |
| | benzene | 1300 g | | | |
| | alcohol | 128 m g/d of 95% ethanol; 9500 gal ethyl ether/d | | | |
| | ethyl chloride | 50 m cf/yr | — | Nov., 53 | — |
| | ammonia | 150 t/d | — | Late, 54 | — |
| | polyethylene | 25 m lb/yr | | | |
| Baton Rouge, La. Naugatuck Chem. | resin-rubber plastic | — | — | — | — |
| El Segundo, Calif. Oronite Chemical | platformer, aromatics | 12 m bbl | — | Spring, 53 | — |
| Richmond, Calif. Oronite Chemical | phenol | 35 m lb/yr | $4. | — | — |
| Calvert City, Ky. Penn-Salt | benzene hex. | — | Part of $900 m expan. program | Early, 54 | — |
| Irving, Texas Petrocarbon Chem. | benzene, toluene, xylenes | 1000 b/d Houdrif. | $1. | Mid-54 | Tears Eng. |
| Big Spring, Texas Phillips Chem. | para-xylene | 5m lb/yr | — | Feb., 54 | — |
| Houston, Texas Phillips Chem. | ammonia | 450 t/d | — | Feb., 54 | — |
| Reichold Chem. | | | | | |
| Tuscaloosa, Ala. Reichhold Chem. | pentaerythritol formaldehyde | 5 m lb/yr 30 m lb/yr | — | — | — |
| Tuscaloosa, Ala. Reichhold Chem. | phenol | 64 mm lb | — | Oct., 53 | — |
| Houston, Texas Rohm & Haas | methyl and ethyl acrylate | — | $8. | — | — |
| Rohm & Haas | acrylates as film formers; Rhople AC 33 emulsion | — | — | Feb., 53 | — |
| San Jacinto, Texas San Jacinto Chem. | ammonia | 40 t/d | — | 54 | — |
| Ventura, Calif. Shell Chem. (Calif) | anhy. ammonia for fertilizer | 150 t/d | $10. | Dec., 53 | Kellogg |

# AT EVERY CHECKPOINT

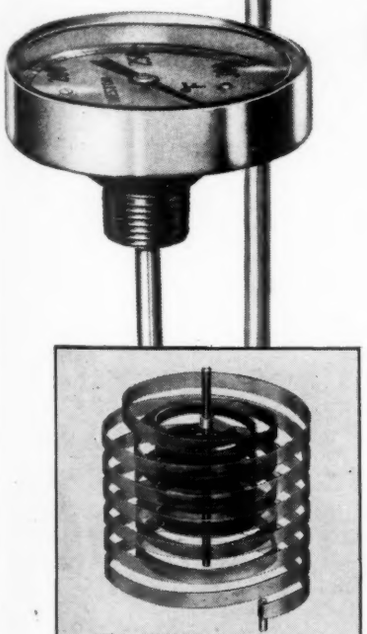


## WESTON *all-metal* THERMOMETERS

***(with Multiple Helix*)***

Here's another typical example of how large processing plants have solved temperature checking problems, and cut thermometer costs besides. With a WESTON dial-type thermometer at every checkpoint, temperatures are read at a glance . . . in far less time, and with far greater accuracy. Their sturdy all-metal construction resists breakage, gives them far longer life on operating equipment. And the exclusive WESTON multiple helix employed assures dependable accuracy during all this long life.

Available in a broad selection of types, sizes, ranges and stem lengths, WESTON thermometers are today standard on all types of mobile and stationary equipment and machines, large and small; as well as on piping, conduit, ducts, etc. Ask your distributor, or local WESTON representative for complete information, or write for descriptive bulletin . . . WESTON Electrical Instrument Corporation, 614 Frelinghuysen Avenue, Newark 5, New Jersey.



***This WESTON-made sensing element is the more costly, non-sagging, multiple-helix. Carefully aged over a broad temperature range for long periods, it assures better accuracy, over a longer life.**

**WESTON** 5537 *Thermometers*

Stocked by leading Distributors

## ROSTER OF REFINING, NATURAL GASOLINE, AND PETROCHEMICAL PLANTS — Continued

Started or completed between January 1, 1953 and March 1, 1954

| Location and Company Name | Kind or process | Capacity | Cost, approx. ($ mill.) | Date comp'd[1] or operating[2] | Builder |
|---|---|---|---|---|---|
| Houston, Texas Shell Chemical | ethoxylene resin (epoxy resin) | triple production to 15 mm lb/yr | — | Dec., 53 | — |
| Norco, La. Shell Chemical | allyl chloride and chlorohydrins (aid in glycerine expan. | 25 mm lb/yr | — | Late, 54 | Fluor |
| Houston, Texas Shell Oil | benzene<br>toluene | 19 mm g/yr<br>33 mm g/yr | — | Spring, 53 | — |
| Chicago, Ill. Sherwin-Williams | phthalic anhydride | 6 mm lb/yr | $.750 | — | — |
| Houston, Texas Sinclair Ref. | feed stock for synthetic rubber | 2000 b/d | — | — | — |
| Marcus Hook, Pa. Sinclair Chem. | para-xylene and other aromatics: toluene, xylene solvents | 10 mm lb/yr | — | Early, 55 | — |
| Vicksburg, Miss. Spencer Chem. | ammonia | 220 t/d | $12. | Feb., 54 | — |
| Chicago, Ill. Spencer Chem. | hexamine | 1.5 mm lb/yr | — | Nov., 53 | — |
| Orange, Texas Spencer Chem. | polyethylene | 45 mm lb/yr | $25. | Spring, 55 | Quaker Valley Constructors |
| Orange, Texas Spencer Chem. | ethylene | — | — | — | Scientific Design |
| El Segundo, Calif. Standard of Calif. | para-xylene | — | Expan. | Sept., 53 | — |
| Richmond, Calif. Standard of Calif. | phenol | 35 mm lb/yr plus 20 mm lb acetone/yr as co-product | $4. | Jan., 54 | — |
| Standard of Calif. | isophthalic acid | 50 m lb/yr | — | — | — |
| Standard of Ind. | detergent alkylate | — | — | Sept., 53 | — |
| Wood River, Ill. Standard of Ind. | iso-octyl alcohol | 10 m lb/yr | — | Dec., 53 | Kellogg |
| Whiting, Ind. Standard of Ind. | polyester film and fiber; paraxylene | 14 m lb/yr | — | Jan., 55 | — |
| Louisville, Ky. Stauffer Chem. | perchlorethylene, carbon tetrachloride, hydrogen chloride | — | — | — | — |
| Marcus Hook, Pa. Sun Oil | benzene<br>toluene<br>xylene | 19 mm g/yr<br>19 mm g/yr<br>15 mm g/yr | $15. | Dec., 53 | — |
| Eagle Pt., N. J. Texas | platformer | 12,000 b/d | — | Jan. 55 | Procon |
| Texas Co. | alkyation unit | 2000 b/d | — | Jan. 55 | — |
| Texas Co. | steam unit | 275,000 lb/hr | — | Jan. 55 | — |
| Texas Co. | storage capacity | 308,000 bbl | — | Jan. 55 | — |
| Trojan Powder, Ill. | pentaerythritol | 10 mm lb/yr | — | Jan., 54 | — |
| Institute, W. Va. Union Carbon & Carbide | naphthalene from coal hydrogenation; also phenol | 300 t/d; to expand to 1000 t/d, 3 mm lb/yr | — | Mid-54 | — |
| Valdosta, Ga. U. S. Industrial Chem. | synthetic resins now: phenolic maleic modified resins soon: polyterpene, terpene phenolics also: alkyds, styrene, poilester resins | — | — | Dec., 53 | — |
| Baton Rouge, La. U. S. Rubber | kralastic, resin rubber plastic | Triple | — | July, 54 | — |
| Nephi, Utah Utah Chem. | ammonia | 270 t/d | — | 54 | — |
| Conroe, Texas Warren Pet. | pentaerythritol et al | 2.5 mm lb/yr | $2. | June, 54 | — |

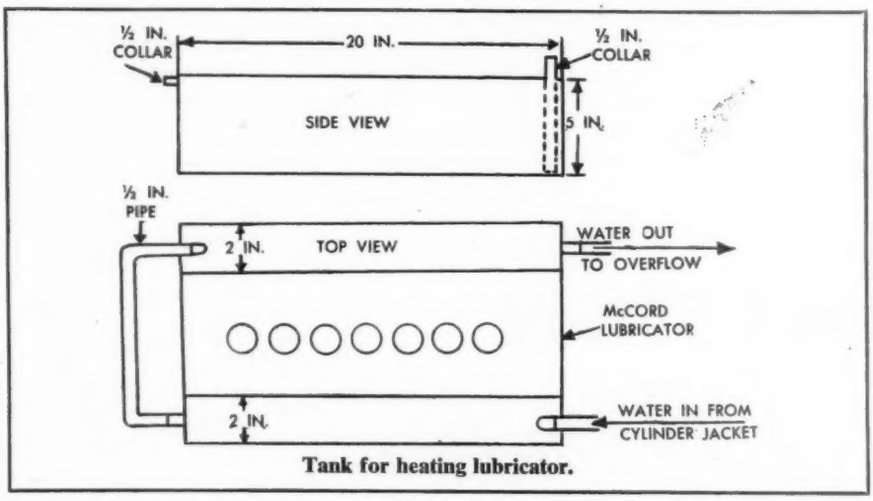
## PLANT AIDS

### McCord Lubricator Heater

W. R. KELSAY*

The 250 hp Clark engine at Carson plant is lubricated by a McCord lubricator. During cold weather it is difficult to keep the oil flowing through the lubricator due to high viscosity. By installing a flat tank (20 by 5 by 2 in.), as illustrated below, to each side of lubricator and flowing hot engine water from the power cylinder jacket through the tanks and into the overflow, heat is transferred through the lubricator walls, thus keeping the oil in a fluid state. A bypass may be installed so that the water may flow directly from cylinder jacket to overflow during warm weather.

*Natural Gas Department, Phillips Petroleum Company, Borger, Texas.




**Tank for heating lubricator.**

### Positive Check Valve[1]

HUGH SMITH and GEORGE ZORNS[2]

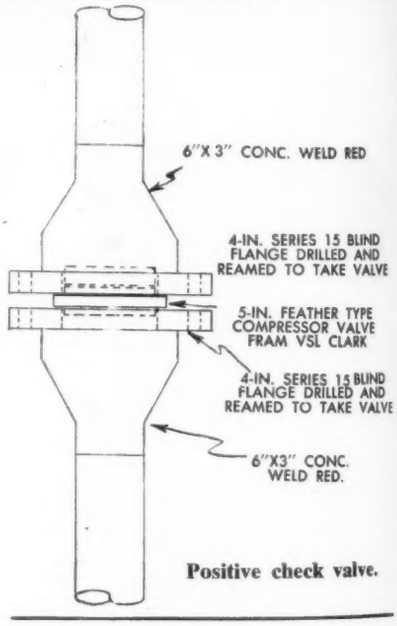
*Purpose:* To give a positive check on air supply.

*Description:* Two 4-in. series 15 blind flanges were drilled and machined so as to take a 5-in. feather type compressor valve. A 6 by 3-in. concentric weld reducer was welded to each flange and also to the piping. These materials were available and were used; however, any desired combination of materials could be used.

This check valve has been in service for several months and has given excellent trouble free service. We have it installed on our instrument air compressor which utilizes one-half of a compressor driven by a type VIII Bessemer engine.

[1]Class D, third prize at NGAA — Permian Basin regional meeting.

[2]Superintendent and chief engineer, Phillips' Hobbs plant.


6"X 3" CONC. WELD RED
4-IN. SERIES 15 BLIND FLANGE DRILLED AND REAMED TO TAKE VALVE
5-IN. FEATHER TYPE COMPRESSOR VALVE FRAM VSL CLARK
4-IN. SERIES 15 BLIND FLANGE DRILLED AND REAMED TO TAKE VALVE
6"X3" CONC. WELD RED.

**Positive check valve.**

### Anti-Knock Compounds

As a result of the growing demand for "Ethyl" antiknock compounds, Ethyl Corporation is expanding its capacity at its Baton Rouge and Houston manufacturing plants by about 15 per cent. The expansion program, according to an announcement by E. L. Shea, Ethyl's president, is being undertaken to assure productive capacity of antiknock compounds.

# "RETAINED VOLATILITY" Seasons

## YOUR MOTOR FUEL

**Make certain your Motor Fuel loses none of its high quality before or after it gets into the customer's tank.**

**Blending with NATURAL GASOLINE will "season" your product with RETAINED VOLATILITY.**

**You can depend on WARREN'S production, transportation, storage and SERVICE for the quality and quantity of NATURAL GASOLINE you need — when and where you want it.**

# WARREN

**PETROLEUM CORPORATION**

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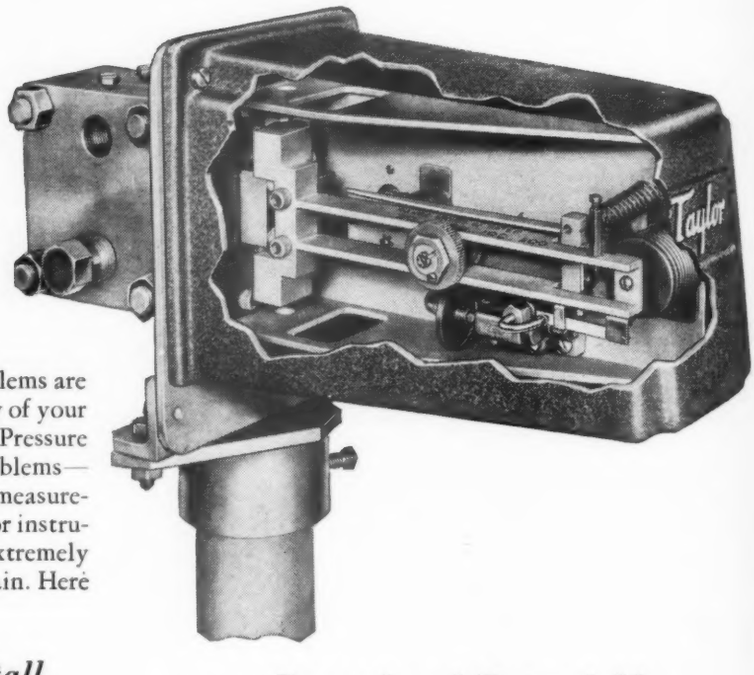
# A FLOW TRANSMITTER

## *That relieves half your headaches*




BECAUSE about 50% of your instrument problems are flow problems, here is a fine remedy for many of your headaches. The Taylor TRANSAIRE* Differential Pressure Transmitter is a specific for most of your flow problems—and many others requiring differential pressure measurement and transmission. This relatively new Taylor instrument has already proved itself in the field to be extremely accurate, simple to install, and very easy to maintain. Here are some of its more important features:

### *Inexpensive and Simple to Install*

1. Simplified piping because it can be close-coupled to orifice flanges.
2. No Leveling—mercuryless dry meter.
3. Side, top or bottom bracket mounting available with 2" pipe stand.
4. No seal pots required—Negligible displacement because of force balance construction.
5. Light weight for easy handling; weighs only 23 lbs.
6. Vent screws for simple, solid filling.

### *Economical—Easy to Maintain*

7. Self draining or venting—no periodic manual venting or draining.
8. Mercuryless—flexible but tough Teflon coated glass fabric diaphragm.
9. Over-range to full body rating with no permanent damage.
10. Purges, if required, can be installed to keep body swept clean.
11. Simple range change by sliding pivot—screw driver trim.

### *Accurate*

12. Relay valve for linearity, minimum hysteresis, fast speed of response.
13. Pressure effect 0.2% / 100 psi.
14. Temperature effect 1.0% / 100°F.
15. Self draining and venting. No errors build up during operation.
16. Hydraulic damping—assures stable air output even on vibrating pipe lines.

### *Rugged and Dependable*

17. Body forged steel or types 430 and 316 Stainless Steel. Working pressure rating, 1500 psi.
18. Weather-proof housing built for tough service and outdoor mounting. Case is self-purging.
19. Force-balance construction — negligible motion—minimum possible wear.
20. Process sealing bellows 3-ply type 316 stainless steel.

### *Adaptable*

21. 100% suppression—continuously adjustable from 0 to 100%. Ideal for liquid level applications.
22. Ten-to-one rangeability in each of 2 forms:
    a. 20-200" water, b. 80-800" water.
23. Side, top or bottom bracket mounting available.

Find out more about this latest addition to Taylor's three-part TRANSET* System. Ask your Taylor Field Engineer, or write for **Bulletin No. 98226.** Taylor Instrument Companies, Rochester, N. Y., and Toronto, Canada.

*Instruments for indicating, recording and controlling temperature, pressure, flow, liquid level, speed, density, load and humidity.*

*Reg. U.S. Pat. Off.

**Taylor Instruments**
**MEAN**
**ACCURACY FIRST**
**IN HOME AND INDUSTRY**

# Trend Is Toward More Automatic Process Control for Improved Products, Lower Operating Costs

*A single automatic analyzer saves $65,000 a year; another conserves $35,000 worth of isobutane annually*

W. S. BOWERS

AUTOMATIC control is well established as an essential part of refining processes today. It is no longer feasible to run a unit manually because so many variables require constant checking if "off spec" production is to be avoided.

In many respects, developments in automatic process control parallel the progress in flight control. In the early days a pilot's success depended on his skill and ability to follow a compass. Flying then was very much an art. When it became necessary to operate at night and under all types of weather conditions, navigational techniques and automatic controls had to be developed.

In refining, too, early operations required skill and experience. In those days, basic instrumentation consisted largely of thermometers and pressure gages. As refineries grew larger and more complicated, automatic controls had to be perfected.

Today, bigger and far more complex units are being built that tax even a good operator's ability to produce specification products under every condition. To assist him, instrument manufacturers and users are devoting a great deal of effort to the development of better instruments and techniques for controlling operating variables.

Some of the factors influencing refinery process instrumentation which this article discusses are in Table 1:

**TABLE 1.**

1. Basic concepts of automatic control.
2. New developments in air operated instrumentation.
3. New electronic control systems.
4. The newest methods of presenting information to the operator with miniature recorders and graphic panels.
5. Automatic control techniques from product composition.
6. Trends toward automatic computer control.

## New Automatic Control Era

In modern refineries, the role of instrumentation is frequently represented by the sketch which is shown on Fig. 1. It is apparent from this that the operator and his management judge a plant's performance from product quality. Instruments are basic tools that help continuously control the primary variables to meet product specifications. The temperature, pressure flow, and level controllers automatically maintain the desired conditions as long as feed remains reasonably constant.

As we visualize it, an automatic unit will function as shown in Fig. 2. Because the human is incapable of staying on the job 100 per cent of the time, we will have to supply him with an electronic assistant called a computer. It will continually collect and evaluate plant operating data, and always apply the necessary corrective action to obtain the desired production. The human operator's main function will be to supply the computer with settings which tell it what feed material the unit will have to work with and the type and quantity of production desired. In this arrangement, the operator will be the unit's supervisor with mechanical and electronic aids to do the tedious and heavy labor. In other words, the operator will supply the brains and the computer the brawn.

Some typical production economies that can be realized from better automatic control will be apparent from Table 2. We have cited here two recent applications from our experience which illustrate the tremendous savings possible with improved automatic controls.

**EXCLUSIVE**

**TABLE 2.**

| | |
|---|---|
| 1 | |
| *The Problem:* To control vacuum tower product streams to a desired viscosity spec. | |
| Value based on differential between lube feed and cat feed | $65,380 |
| *Recommended:* Continuous recording viscosimeter for each stream. | |
| *Cost* | $ 5,100 |
| Payout after taxes | .8 yr |
| 2 | |
| *The Problem:* To recover isobutane in excess of 5% from alky unit spent butane stream. | |
| Value based on differential between alky feed and fuel gas | $34,450 |
| Continuous Plt. stream analyzer controller to divert stream to recycle | $ 7,000 |
| Payout after taxes | 0.5 yr |

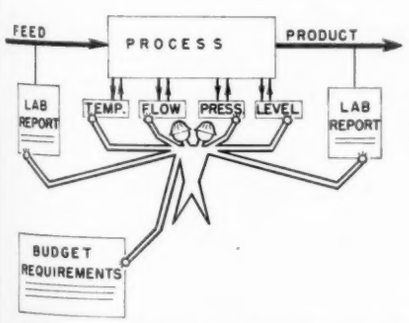



**FIG. 1. Diagram of automatic control, with a human operator directing each action.**

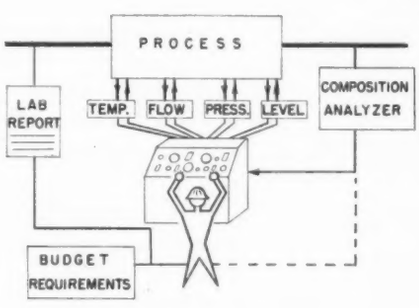



**FIG. 2. An electronic computer carrying out automatic process control.**

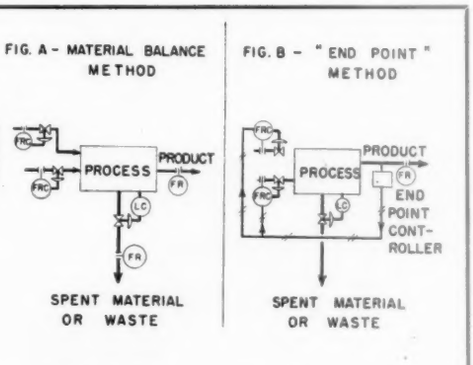



**FIG. 3. Diagram of basic automatic control techniques.**

**The Author**

W. S. Bowers heads a pumping and instrumentation group in the general engineering division, Standard Oil (Ohio) at Cleveland, Ohio, of which city he is a native. A chemical engineering graduate out of Alfred and Illinois Universities, he has the background of American Cyanamid as chemist, the Bristol Company as instrument engineer, and as designer of instrumentation systems with the H. K. Ferguson Company, joining Sohio in 1948.

In evaluating the instrumentation required for these applications, we recommended:

1. **A continuous viscosity analyzer to help us recover an average of $65,380 per year of "off spec" lube plant feeds.**
2. **An infra-red analyzer to conserve approximately $34,450 per year of isobutane for alkylation feed.**

## Basic Control Techniques

There are two basic methods for applying automatic control to our process operations. Fig. 3A shows the technique that is commonly called, "material balance" and Fig. 3B shows the product composition or "end point" method. In the former, we meter all of the ingredients going into a reaction to obtain the desired product. In the latter, we measure the product composition or something directly related to it and alter operating conditions to hold quality constant.

The material balance method has obvious disadvantages where composition of a feed component varies greatly. When this occurs, products can be lost because the controller cannot automatically detect or compensate for it. It is an inexpensive and satisfactory approach, however, when feed composition is reasonably constant or plenty of tankage and adequate mixing equipment are provided. This method is frequently used in gasoline and lube blending operations, in water treating, and on some gas plant towers.

In theory, the "end point" system is far superior to the "material balance" because it measures and controls directly for the ingredient we desire. It is also free of many time lags inherent in the "material balance" arrangement. Actually, there is still a lot of work to be done to provide instrumentation which will make the practice match the theory.

Every automatic control system has lags. Control engineers recognize this and carefully examine every application before applying equipment. Their objective is to minimize the unfavorable effect of:

1. **Measurement lag or the time it takes an instrument to sense a change.**
2. **Transfer lag or the time it takes a signal to get from the sensing element to the controller and back to the valve.**
3. **Process lag or the time it takes for the corrected action to result in a significant change of the original measurement.**

The standard process heater arrangement shown in Fig. 4 illustrates how these lags affect the quality of our results. If we use a heavy walled thermowell located in the transfer piping, we will have a less sensitive response and poorer results than with a well located in the header box. Similarly, an electronic thermocouple instrument will respond faster than a mechanical galvanometer or bulb type controller. Likewise, a direct fired heater can be controlled much closer than one with a bridge wall because it has less inertia and heat capacity.

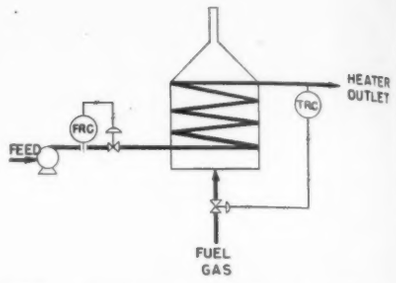



**FIG. 4. System of control of a process heater.**

## Force Balance Systems

In the last five years, instrument manufacturers have perfected a pneumatic control system that has greatly reduced measurement and transfer lags. It has also resulted in far less maintenance than we found necessary on conventional instruments. This new design has been called "force-balance."

Basically, the system operates like the see-saw shown in Fig. 5. The measurement force is normally balanced by an equal and opposite air pressure. When the measurement goes up or down, the air pressure increases or decreases just enough to balance it. This measurement signal is then transmitted to a recorder or used to operate the control valve or both. The entire system operates in balance except when there is a change in measurement or a control deviation.

A complete force balance system is shown in Fig. 6. In this flow metering installation, the transmitter and con-

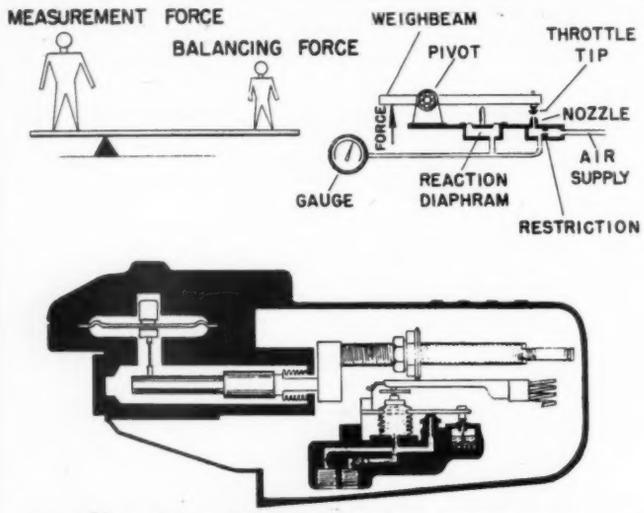



**FIG. 5. "Force-Balance" principle of control, in a pneumatic transmitter.**

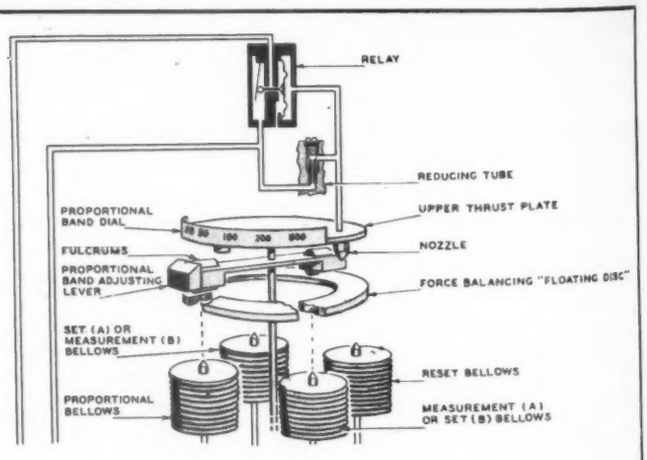



**FIG. 5A. "Force-Balance" principle of control, in a pneumatic controller.**

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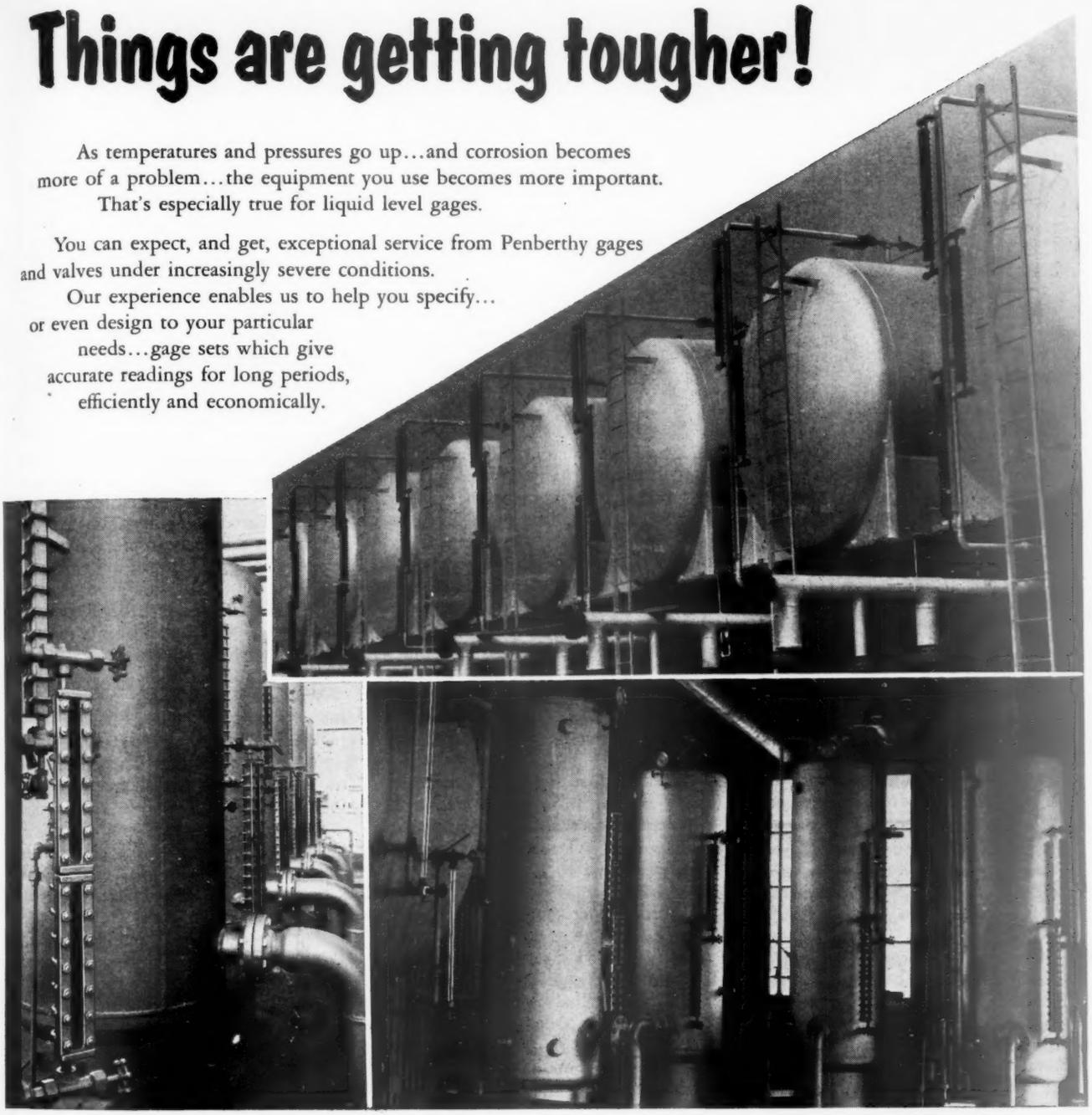

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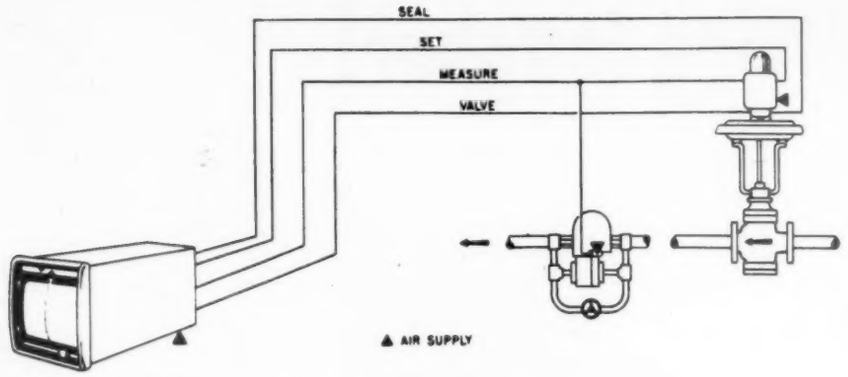



**FIG. 6. A diagram showing the complete "Force-Balance" arrangement for flow control.**

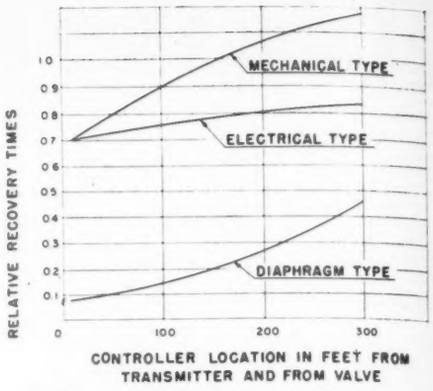



**FIG. 7. Relative time required for control recovery with various types of transmitters and controller locations.**

troller operate on the force-balance principle. There are both process and mechanical advantages in this arrangement since it is a "pneumatic balance" rather than mechanical "motion balance" hookup.

Let's evaluate these advantages:

**First, there is less measuring lag because the transmitter is close coupled on the process line at the point of measurement.**

**Second, there is less transfer lag since the controller can be mounted close to the transmitter and valve. For operating and maintenance convenience, the recording control station may still be centrally located on the panel board.**

In addition, the force-balance controller responds more quickly because it has less friction or lost motion (no linkages) and at least twice as much air signalling capacity as the equivalent conventional board mounted controller.

The maintenance advantage of the force-balance over the conventional motion balance system lies in its unit construction. This permits plugging in replacements about like tubes in a radio set. Thus, there is a minimum of process downtime and repairs can be made under ideal working conditions in the shop. Operating experience in one of our refineries shows not a single force-balance controller breakdown in over three years of operation. In the case of the flow transmitters, there have been less than half as many maintenance calls on the force-balance as on conventional mercury monometers in the five years of operation. In addition, the instruments themselves have made possible a number of applications which were not practical previously with heavy stocks or slurries.

Fig. 7 graphically demonstrates the process advantages of a "remote set" diaphragm type force-balance control system. This is the name applied to the arrangement with the controller located at the process instead of on the panel board. You can see that the recovery time with the "diaphragm" controller is much shorter than any other combination of instrument components. This is particularly important in a flow control system where the measurement and control valve are so close together and the process capacity is measured in seconds rather than minutes.

### Electronic Control Systems

One of the new all-electronic measurement and control systems is shown in Fig. 8. This type of instrumentation brings us three promising features:

**First, added speed of response over greater distances. Thus, even greater centralization is possible.**

**Second, basic adaptability to automatic computer type instrumentation.**

**Third, more potential reliability with less maintenance.**

All of us are, of course, familiar with the electronic temperature instruments which most refineries have used for more than 10 years. It has been universally recognized that they established new standards of instrument sensitivity and operating reliability. The complete electronic control systems are a relatively recent introduction which also promise to establish higher standards of sensitivity and reliability. The principle reason for the delay in the adoption of an all-electronic control system is the high cost of an explosion-proof installation. Electronic controllers have worked well in England for a number of years where electrical codes are much more liberal.

We understand from the manufacturers that four electronically controlled refinery units have been designed and are being constructed for use in the United States. One of these is for a "major" refiner. The design utilizes explosion-proof components for field mounting and standard recorder controllers at the main board. These installations are scheduled to go on stream late in 1955.

At the present time, pneumatic controllers are generally very adequate at a lower cost. One of the things which promises to change this in the near future is an amplifier device called a transistor. This is a hermetically sealed electronic tube about the size of a thimble. It will take the place of the conven-

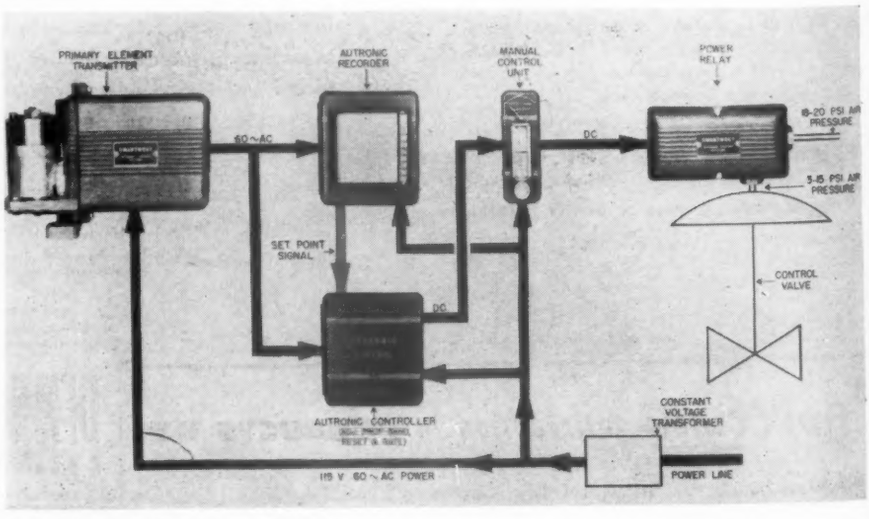



**FIG. 8. An electronic controller.**

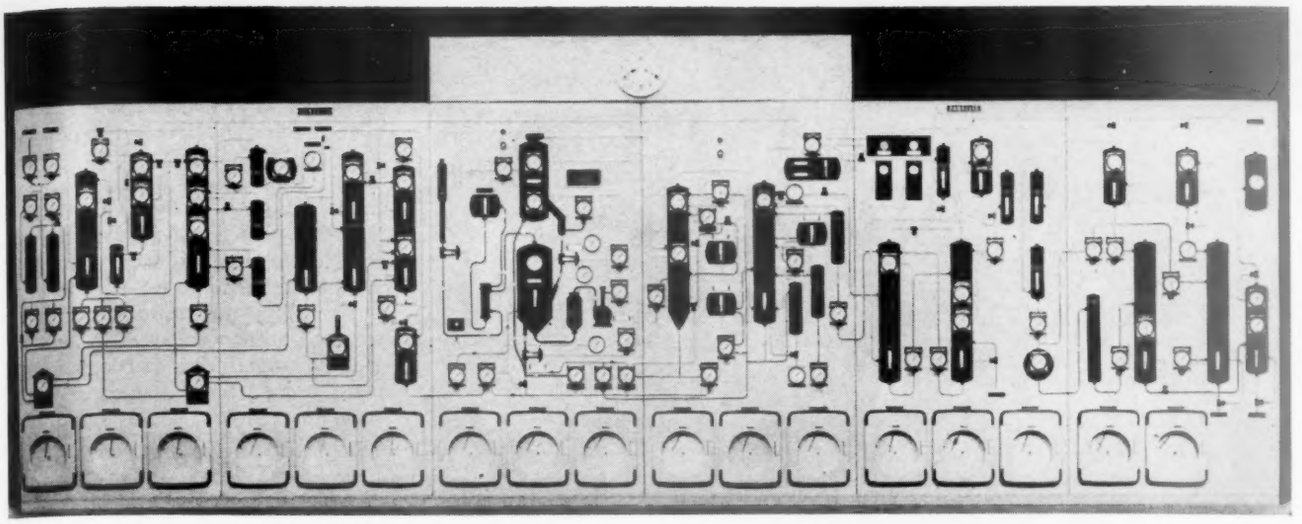


**FIG. 9. A graphic panel in the Rock Island refinery.**

tional glass radio tubes and probably reduce or eliminate the need for explosion-proofing. Its greatest potential advantage, however, is much longer life expectancy. Such units will last for five or more years, whereas the best tubes now give us about one year of service.

### Presenting Operating Information

Although our ultimate goal is a faster and more automatic evaluation of process data, most people will recognize the advantage of building up to this gradually. Before we can ask an electronic device to perform the task, it is necessary that operating, design and maintenance personnel fully understand not only the process itself but how instruments function in it.

The refining industry recognized this more than twelve years ago when Houdry cat crackers were introduced. Their panel boards included a supervisory control diagram for better and safer operation. This was an essential feature because the unit was much more complicated than the Thermal cracker and introduced the first 100 ft and up panel board. Our Houdry unit control board was 125 ft long. A single operator couldn't possibly follow the unit's instrumentation so the job had to be handled by three. It was then that we began to look for a way to cut down the board size and make it more intelligible to *one* operator.

During the last war, these diagrammatic panel boards proved so helpful in training that designers began to think of extending this feature to other units. Many people visualized putting the instruments themselves into a simplified flow diagram. Of course, it wasn't practical with conventional sized instruments. One alternative that many users adopted was to put a little card diagramming the function of the instrument inside each case. This method was used by us on at least three postwar units. Operating personnel found it very helpful in training and they are still referred to when explanations are necessary.

The earliest graphic panels on which miniature instruments were located in a simplified process diagram were built in 1948. They were designed completely around the newly developed force-balance control systems. The first ones utilized indicating control stations in the flow diagram with multiple pen recorders on the side panels for important variables or accounting records. The theory was that the operator would be more interested in deviation from control point while the supervisor was primarily concerned with a few critical "trends."

The early panels were built for small refiners and frequently included crude topping, cat cracking, and gas plant operations on a single board. A typical installation is the Rock Island Refinery Unit shown in Fig. 9. These installations were almost universally successful. They brought control improvements, reduction in panel board size, and ease of operator training. In those days, few people recognized that there would be operating and maintenance problems arising from the separation of the trend recorders and the control station.

The first miniature instruments were designed around an indicating controller because it was easier to build and much lower in cost. Most people felt that multi-point recorders for trend or accounting purposes would be quite adequate. One explanation for the acceptance of this arrangement by small refiners lies in the fact that most of them had no inventory of instruments or established panel board preferences. Many had no instrument departments so that the reduction in maintenance and improved controller operation was a big asset over their previous experience with conventional instrumentation.

Sohio was the first "major" refiner

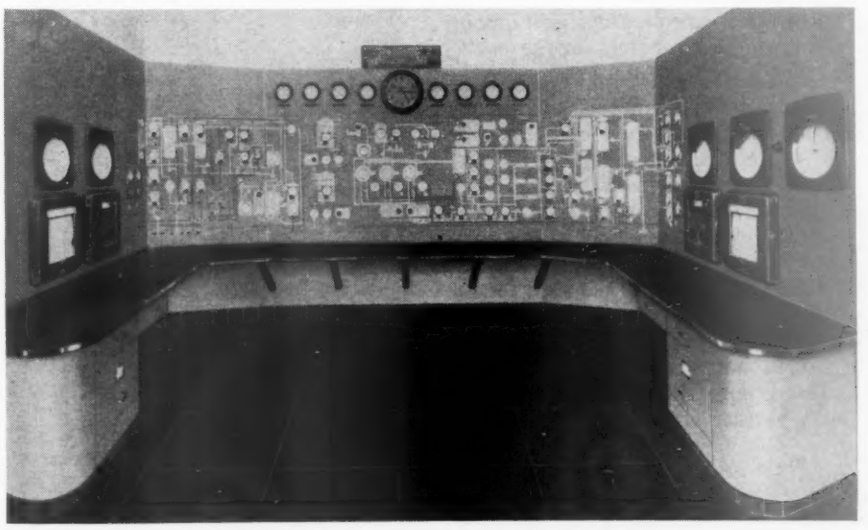


**FIG. 10. A console graphic panel, Standard Oil (Ohio), for solvent extraction and dewaxing operations.**

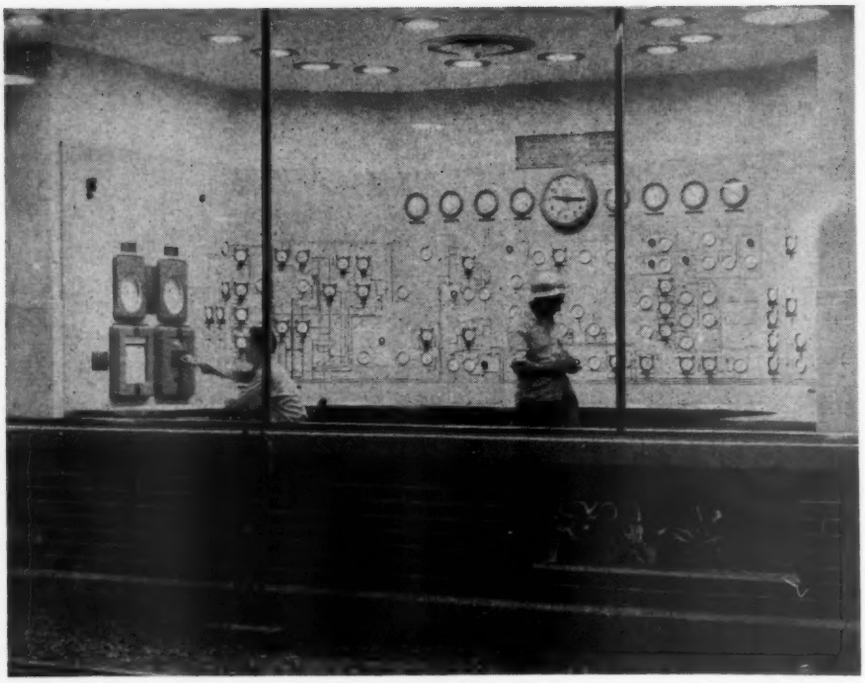


**FIG. 10A. Console graphic panel, in a Sohio lube plant.**

to build a complete graphic panel. It was the console shown in Fig. 10 for our Lima lube plant. Indicating control stations were located on the flow diagram in the center of the board with multi-point recorders for each indicator on the wing panels. During the course of the startup, a number of operational difficulties were encountered which revealed three things to us:

*First, the diagram itself was a big help for operator training.*

*Second, the compact size of the panel enabled one control board man to handle the instruments quickly and easily.*

*But! — the absence of continuous trend records was a tremendous handicap; esecially, during upsets. If the operator wanted to know the trend, he had to search for it among one of the six points on the multi-point recorders.*

In spite of this, however, the process superintendent and unit operators felt that the graphic presentation was desirable for future installations. They indicated that it had been a big help to them during startup and would continue to be valuable in their daily operations. They stressed the need for replacement of the indicators with continuous miniature recorders.

We found the same to be true of a similar graphic panel on our Lima refinery vacuum unit.

### New Miniature Recorders

Miniature recorders were soon introduced and we tried them on a new panel for our Cleveland TCC unit shown in Fig. 11. Although they made a tremendous difference in the acceptance of the panel by the operators, they introduced new maintenance problems to the instrument men. The first miniature recorders were very flimsy in construction and poorly designed for accessibility and troubleshooting. Although some of the mechanical difficulties were remedied, the feeling persisted that no new "graphic" panels should be built until better miniature recorders were made available.

Similar difficulties on other refiner's units soon convinced the manufacturers that more rugged constructed, better designed instruments were necessary. At least three good designs have been made available in the last two years. The newest ones have overcome previous limitations and incorporated several desirable features. Fig. 12 shows one of these miniature recorders that we used on our Toledo alkylation unit graphic panel. This particular instrument proved more rugged and easily accessible than any earlier design which we had used.

Like the other components of the force-balance instrument family, it is unit-constructed so that replacements can be plugged in. If the recording mechanism needs to be worked on, it is readily accessible for minor adjustments either from the front or back of the panel.

Major repairs can be made in the shop while a new unit is plugged in or with the instrument on manual control bypass. The chart is equal in size to the conventional circular one and easily readable. Five hours of record are visible without opening the instrument and twenty-four hours can be seen by unrolling the chart. A useful feature is provided so that the chart can be conveniently torn off and planimetered or circulated to the unit supervisor. There is a continuous valve position indication so that the operator knows what

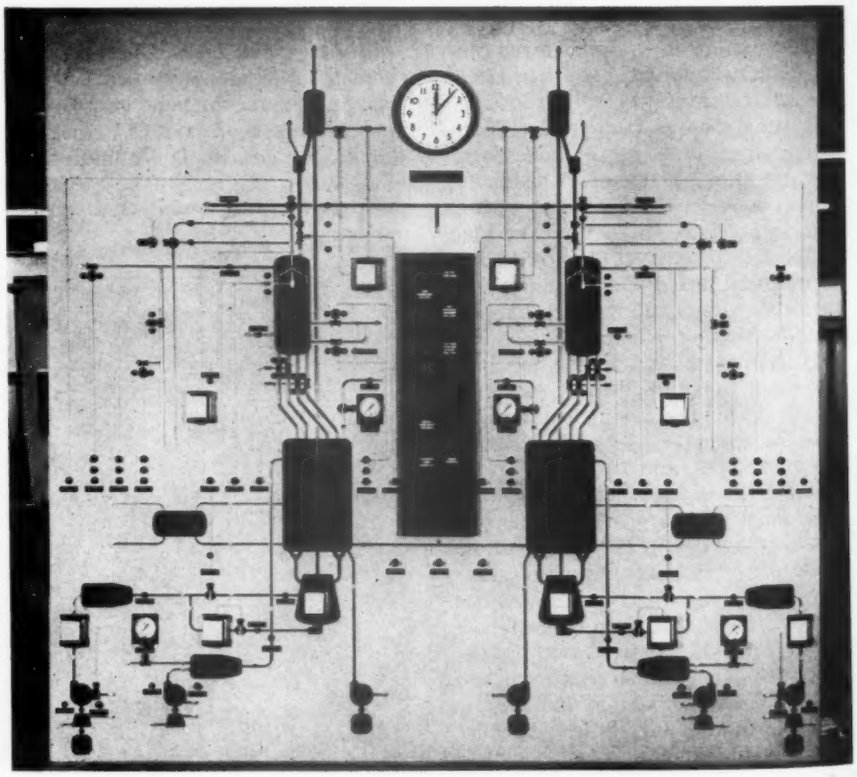
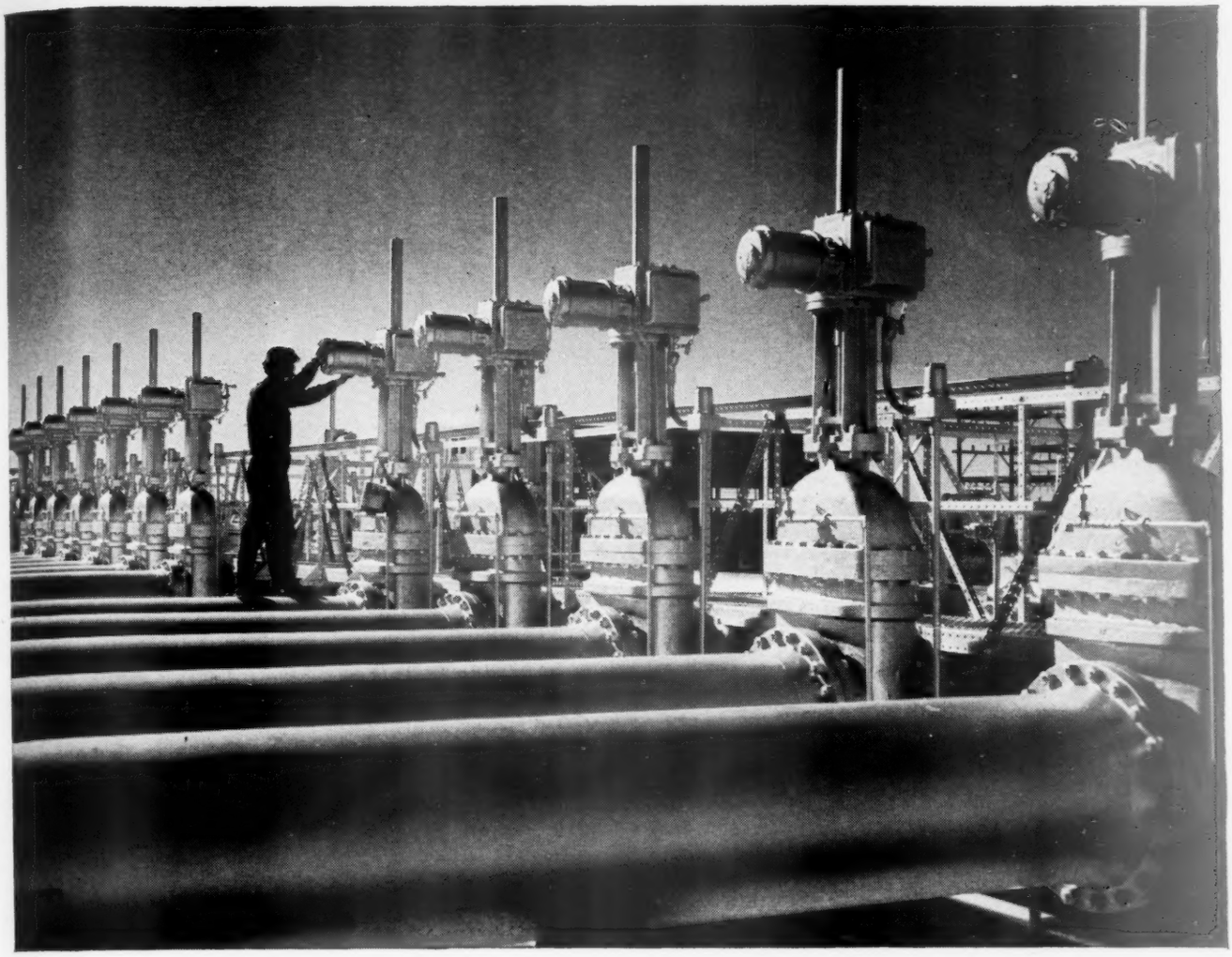


**FIG. 11. Graphic panel controlling a Thermofor catalytic cracking unit, Cleveland No. 1 plant.**



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is happening at all times. Operating adjustments are extremely simple. In fact, the manual automatic transfer switch is much easier to operate and more foolproof than any that have ever been available to us.

A new planimeter is also available for the strip charts. Incidentally, because of the rectangular coordinates, it is easier to use and far more accurate than the radial planimeter which we now employ for circular charts.

In short, the new miniature recorders are generally far better performers, both from an operating and maintenance standpoint, than any we've ever had. About the only feature which some of our supervisory people object to is the five hour instead of 23 hours of record which is visible to them (without opening the case) on their daily rounds.

When we designed our Toledo alkylation unit graphic panel shown in Fig. 13, we felt that we had progressed a long way from the one we built three years before on our Lima lube units. Based on our previous experiences, we incorporated features to provide a panel of convenient size, good layout, pleasing color harmony, high quality of instrumentation, and adequate maintenance features. In addition, we added one innovation (for us) which we find very beneficial. This is a combined operator and temperature punch desk similar to that shown in Fig. 14. On previous units, instrument readings were logged by an operator who walked over to each instrument. Most of us felt that when he was filling in his log sheet in this way, the operator wasn't likely to see deviations or upsets on the other instruments. With the desk centrally located, however, he's in a better position to see all of the instruments easily. This is important because on many units a control operator spends a great deal of his time on the log sheet.

The initial startup and first six months of operating experience with the new Toledo alkylation unit went a long ways towards proving the value of "force-balance" instrumentation, miniature recorders, and the "graphic" method of presentation. For the first time in our experience, the unit was brought up on "full" automatic control and except for a few minor adjustments has performed *very* well since then. This was accomplished with less operator and instrument maintenance requirements than we'd anticipated or found necessary on previous units. Good instrumentation has also been credited with helping in the production of higher quality and greater quantities of product than the unit was designed for.

### "End Point" Control Techniques

One of the most promising trends in instrumentation is the great amount of development work which is going into plant devices to measure a product composition or "end point." Some of the special physical properties which have already been useful for this purpose are density, specific gravity, refractive index, color, thermal conductivity, viscosity, paramagnetic properties, and pH. All of these properties for "end point" control have been applied on operating units in the chemical and refining industries in special adaptations. Greatest need has been for general plant type analyzers, however, to continuously measure a specific chemical compound in a multi-component mixture.

The two devices that have shown the most promise were developed from well-established laboratory instruments. They are the mass spectrometer and the infra-red analyzer. The "plant type" mass spectrometer is now being used by at least two large refiners on operating units. It is commercially available, but expensive. Infra-red analyzers are now sold by at least four suppliers for continuous plant stream measurements. In the last two years they have been used extensively in the chemical and refining industries to quantitatively measure and control such gases as butane, methane, isobutane, carbon monoxide, carbon dioxide, acetylene, ammonia, acetone, and others in a multi-component mixture.

Two applications for the infra-red analyzer in refining have been widely publicized:

One is the detection of carbon monoxide in the flue gases from a fluid cat cracker in order to minimize after-burning and conserve catalyst. This has been reported faster and more effective than the measurement of oxygen in the flue gases.

It has also been used to divert isobutane from spent butanes in alkylation plants. The two installations on our Toledo alkylation units have been highly successful detecting an excess of isobutane in the debutanizer overhead and diverting it to feed recycle instead of dumping it when it reaches a predetermined concentration. These infra-red instruments are also used by the operator to control the feed ratio of isobutane to butylenes in the reactor. The instruments have been *very* helpful in conserving valuable products and shortening the recovery time during proc-

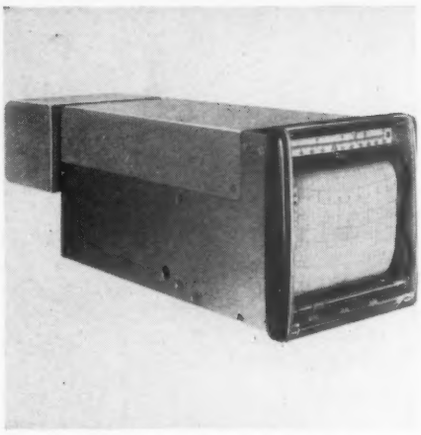

**FIG. 12. Side view of a miniature recorder.**

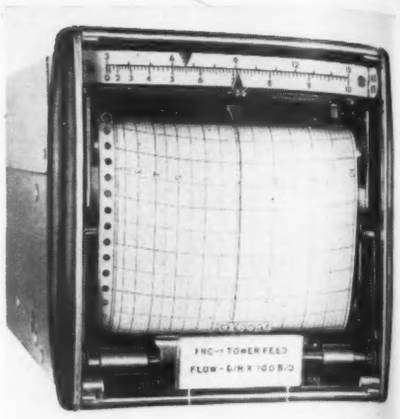

**FIG. 12A. The same miniature recorder, front view.**

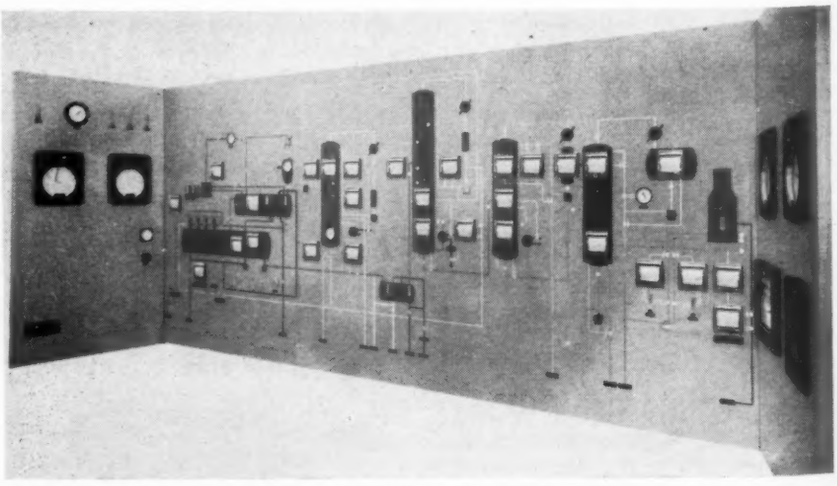

**FIG. 13. Graphic panel for the automatic control of an alkylation unit.**

FIG. 14. Control operator's desk, where all operations center.

FIG. 15. Infra-red plant stream analyzer, one of the most efficient and effective of the new automatic instruments.

ess upsets. On this basis, the original $7,000 capital investment paid out in less than six months.

Actual equipment required for a typical installation is shown in Fig. 15. Physically, the unit is not much bigger or more complex than the average instrument transmitter and receiver controller. The only regular attention it requires is weekly standardizing. Repairs when required are by replacement as practically all critical parts are plug-in units. In general, maintenance requirements have been found to be only slightly more involved than for a typical electronic temperature instrument. They are within the scope of an average instrument maintenance department and have been handled by such groups in our plants.

At the present time the analyzer is only suitable for gas measurement, but a great deal of work is being done to develop it for liquid streams. The plant type instruments are now available at a cost of from $4500 to $6000. It is expected that with wider application and improvement in manufacturing techniques, this could be cut by one third.

### Interconnected Controls and Computer Instrumentation

Basic principles of a computer control system and its method of operation are best illustrated by the pneumatic cascade controls that have been

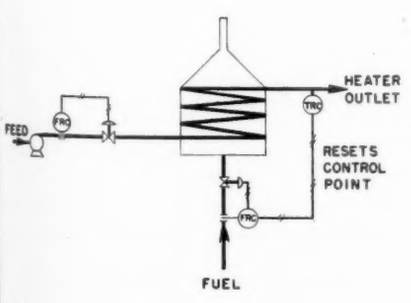


FIG. 16. Diagram of a process heater control system, which operates on a fluctuating gas supply; compare with Fig. 4.

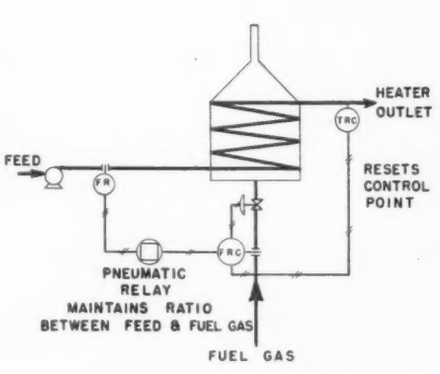


FIG. 17. Control diagram for a process heater which operates with fluctuating feed rate and also fluctuating fuel gas supply.

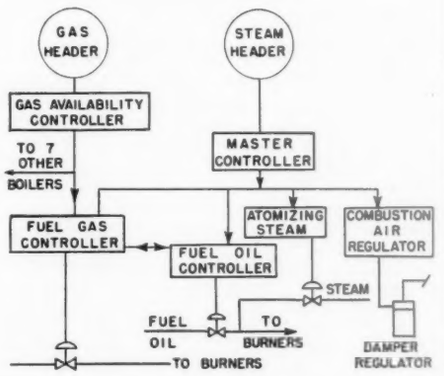


FIG. 18. A complete schematic system for automatic combustion control in a refinery.

in use for some time throughout industry. In their simplest form, they utilize a primary controller to reset the control point of a secondary instrument. This in turn operates a control valve. A typical application that we have used for years is shown in Fig. 16. In this system, a temperature controller on the heater outlet resets a flow meter on the fuel gas line. The temperature instrument measures product quality as outlet temperature. Its function is to correct primarily for feed temperature variations and changes in fuel gas Btu. The flow meter corrects for gas rate changes resulting from density and pressure fluctuations long before they affect the outlet temperature. Objective here is to minimize system lags or process variations at their source before they can affect the product quality.

An extension of this principle interconnects another variable that is feed rate. By this means process limitations and instrument lags are further reduced. Fig. 17 shows the control system we employ on several hot belt heaters. Here we make an additional correction for a varying charge oil rate to the heater. The signal from this meter will tell the fuel control valve of a load change before it can upset the system. Of course, this arrangement is only justified when sudden variations in oil flow are encountered, such as frequently is the case on a hot belt system.

A further extension of this principle of interconnected master and secondary controllers is seen in a complete combustion control system. Typical is the one we utilize in our Lima refinery boiler house. Fig. 18 shows a basic diagram of the system. The master controller measures steam header pressure which is product "end point." It then signals a fuel controller and simultaneously a combustion air controller to open or close valves and dampers as required to hold the steam pressure constant. An additional refinement is the gas availability regulator which automatically assures the burning of waste fuel gas when it is available. You can see that the interchange of fuels and the proper adjustment of combustion air is carried on for a large number of boilers without referring back to the master controller. The master can override secondary instruments at any time, however, or initiate an overall operating change as soon as an excess or deficiency in steam is detected.

In each of these systems, the basic control of a process resides with the primary or master controller to hold "end point" at a predetermined setting. Changes in any of the contributing variables, are resolved directly by the secondary controllers. Such an arrangement is now practical pneumatically with a relatively simple control system where the product is easy to handle and the process lags are fully understood. For the complex products and processes of refining, much better and faster systems will be required. These appear to be practical only with electronics.

### Conclusion

In this article we have reviewed some of the more important developments and recent trends in instrumentation. All signs point to a new era of progress in our present measurement and control techniques followed by the development of semi-automatic and automatic process control by means of electronic computers. Without a doubt, many equipment problems will arise before this instrumentation is completely acceptable to industry. The ultimate solution will require a cooperative effort between the instrument manufacturer and user. Now is the time for process, instrument, and maintenance groups to concentrate their efforts on improving their present process control techniques and begin thinking for the automatic era. * * *


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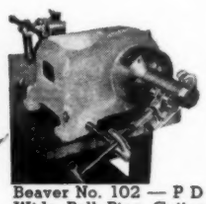

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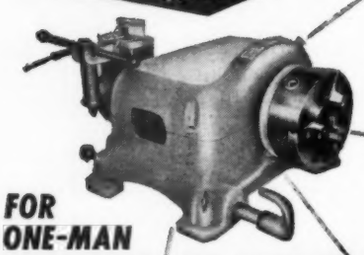

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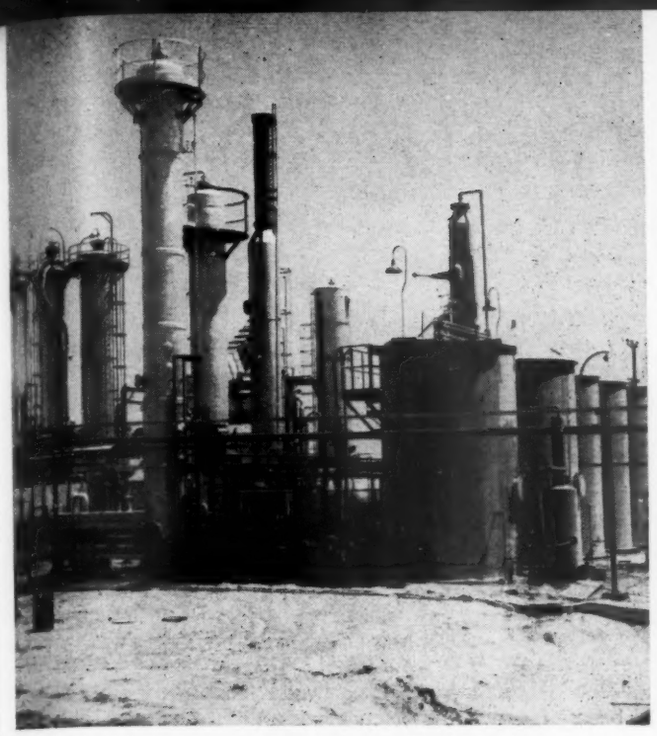
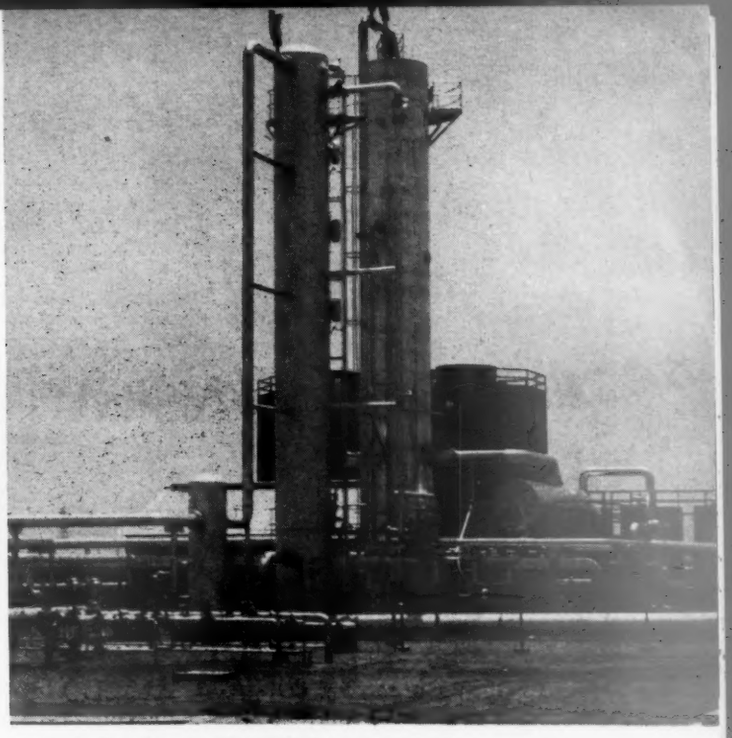


Old-fashioned "pressure distillate doctor treating" system of the type going out of use rapidly in modern refineries.



A typical amine treating unit for removal of hydrogen sulfide from gases and vapors.

P 720.2

# Status of Progress in Chemical Treating of Petroleum Fractions

*Selection of additives, reagents to correct specific problems in products is better than "shotgun" type treatment with a single agent for all purposes*

V. A. KALICHEVSKY*

PETROLEUM refining is a dynamic industry. Every few years new processes are developed, and after comparatively short service expensive plants are dismantled in order to meet the keen competition existing between some 270 individual enterprises and 350 refineries in this country alone. Chemical treatment of petroleum fractions is one of the major phases of petroleum refining and its progress is equally fast. During the early days of the petroleum industry few chemicals were used but the continually growing demand by modern machinery for high quality materials requires application of chemicals in the manufacture of nearly all refinery products. With the rising cost of crude oil, materials and labor chemical treatment offers not only a method for improving oil quality beyond the limits attainable with the hydrocarbon substances but also a way of lowering manufacturing costs.

### Chemical Treating Processes

Chemical treatment is not a substitute for all the refining methods such as distillation or cracking although it contributes to the uniformity of refinery fluctuations in plant operations. Recent developments in refining technique introduce difficulties in separating chemical refining from other processing operations. For instance, cracking catalysts are at the same time chemical refining agents while solvents are generally considered to be chemical refining agents although their action is physical. Likewise the same materials may act as cracking, isomerization, or treating catalysts depending on the conditions employed.

Chemical treating methods may be divided into three distinct types: Subtractive refining, application of additives and transformation of undesirable into desirable substances by hydrogenation, condensation, polymerization, and other chemical reactions. Subtractive refining is done by the use of chemicals or solvents and may be destructive or indifferent with respect to the substances removed. In the old times sulfuric acid was almost the only reagent employed and the undesirable petroleum constituents were discarded in the form of sludge. The high cost of crude oil and chemicals and the small margin of profit in petroleum refining operations require at the present time full utilization of the crude oil fractions and chemicals. Many refineries manufacturing a wide variety of products abandoned completely the use of destructive reagents like sulfuric acid while others reduced their application to a bare minimum. This was made

*Consulting chemical engineer, Magnolia Petroleum Company.

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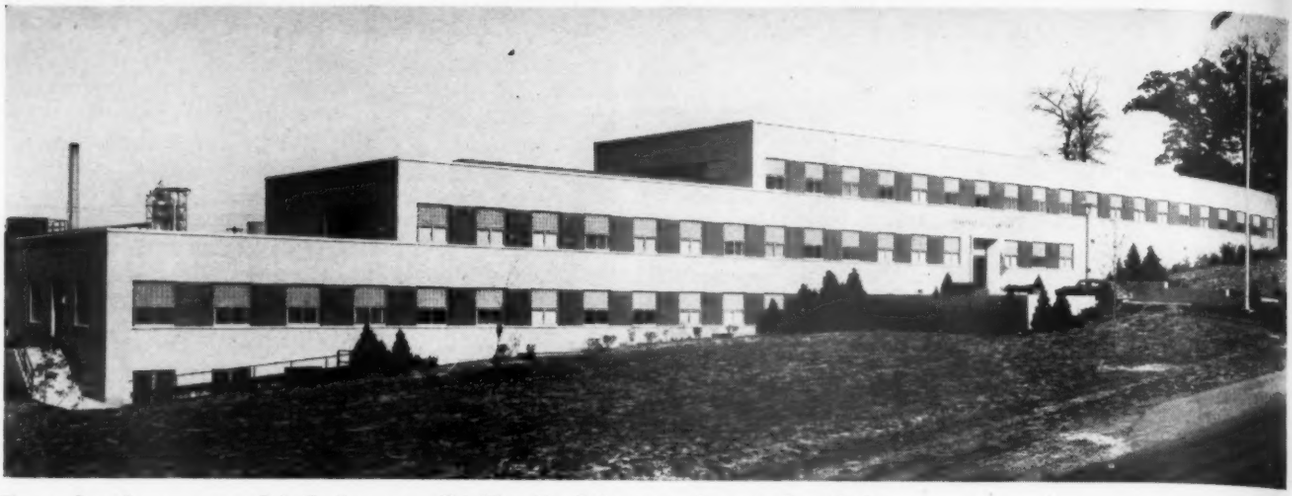


**Research and more research is the key, as realized by all refining executives, to the solution of an increasing number of technological problems.**

possible by the use of solvents that permit recovery of all petroleum components in their original state. Refining with formerly little investigated alkaline reagents has lately become of considerable importance and still offers attractive possibilities for the future.

### Modern Approach to Chemical Refining

Progress in equipment design and operating technique reduced mechanical losses of oil and reagents to small fractions of one per cent. This opened new possibilities for the selection of refining agents not yet fully utilized. Expensive chemicals were little studied in the past as commercially feasible treating reagents because of the inevitable waste. However, they may be very practical if they are regenerated. The use of platinum costing close to fourteen hundred dollars per pound in reforming processes is an example of this idea. Similarly potassium hydroxide has many economic advantages over sodium hydroxide as a treating agent although its cost is more than double that of sodium hydroxide. Practically all modern refining methods regard regeneration of the reagents as an integral part of the process; thus making the selection of chemicals for petroleum refining a secondary consideration with respect to their initial cost. This opens widely the future field of research on chemical treating of petroleum.

Use of additives in petroleum products is not a recent invention although their extensive development began only a few decades ago. The beneficial effect of the presence of sulfur in certain lubricants has been observed for a century and was patented by R. R. Brown as early as 1859. Improvement in odor of petroleum fractions by additives like camphor had been recommended by H. B. Brace and W. T. Swart in 1866. Addition of peroxides to motor fuels had been suggested by G. B. Selden in 1909. The field of additive applications has been expanded rapidly since the late 1920's and will undoubtedly continue to grow for many years. It is sometimes apparent that in the lubricating oil manufacture, the hydrocarbon constituents arising from the crude oil fractions are reduced to the status of convenient vehicles for chemicals which impart the important service characteristics to the products while in fuel oil production, hydrocarbons are the sources of heat with their combustion characteristics altered at will by the use of additive.

Processes converting the undesirables into desirable fractions by changing molecular structure of the petroleum constituents are widely used in petroleum refining, but only a few of them like hydrogenation fall within the scope of chemical treating methods. The beneficial effect of hydrogenation on the stablity of petroleum fractions was noticed by J. A. Dubbs in 1892, but 40 years elapsed before the process found commercial applications after suitable catalysts were discovered and a comparatively cheap method for producing hydrogen was found. Recently a considerable improvement in the process has been introduced by utilizing hydrogen released from the crude oil fractions themselves. It is of interest that the quantity of hydrogen in crude oil varies between 11 and 14 per cent while the hydrogen content of benzene boiling within the gasoline range is 7.7 per cent; that of toluene is 8.8 per cent; and that of xylenes is 9.5 per cent or considerably less than the hydrogen content of the crude oil.

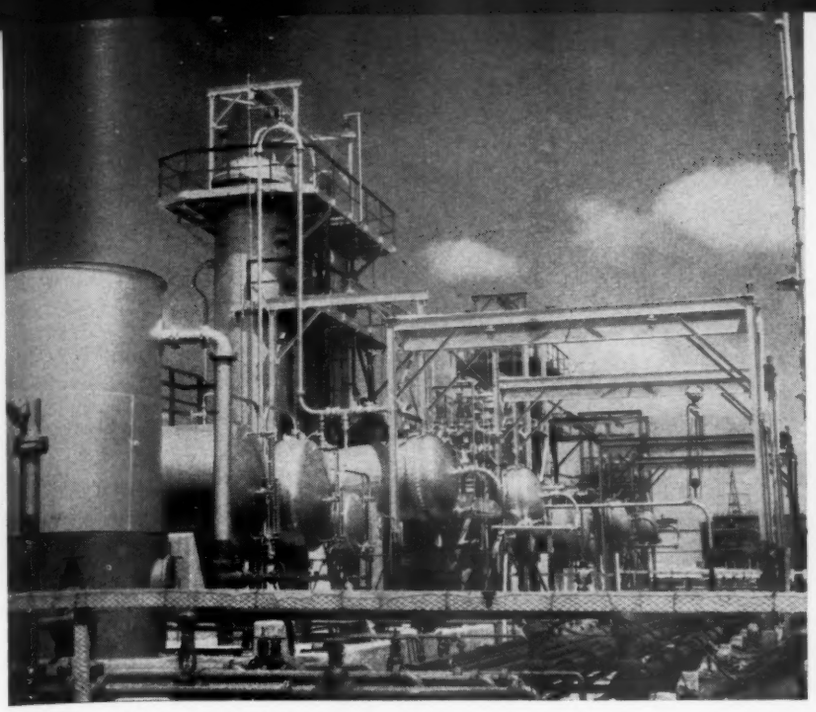
Even the hydrogen content of pentamethyl benzene boiling within the kerosine range is still below 11 per cent present in petroleums poor in hydrogen, which shows the possibility of converting all the crude oil into the low boiling and stable fractions with a simultaneous release of hydrogen. In catalytic reforming about 10 per cent of hydrogen present in the charge stock is set free. Such processes, however, cannot be classified as chemical treating processes even if the resulting products do not require further refining.

For a number of years the general trend of chemical refining has been toward the use of solvents, catalysts, and additives. This trend will undoubtedly continue into the future as it offers the most economical utilization of our petroleum resources. The present tendency of preparing semi-synthetic or synthetic materials from crude oil might simplify some of the chemical treating problems by reducing the number of chemical constituents in the refinery products and thus facilitating separation of the undesirable and desirable substances.

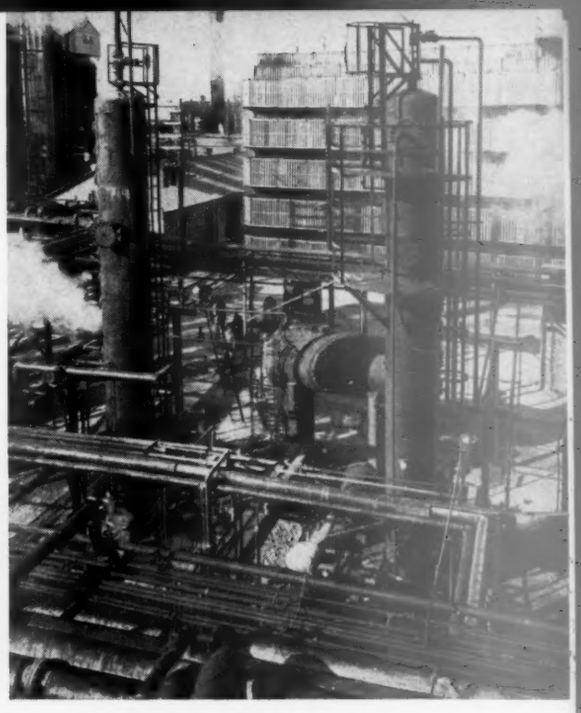
Application of proper solvents offers the greatest possibilities in this respect while additives permit manufacture of continually improved materials. Chemical treating processes involving the use of catalysts will probably merge with other refining processes like reforming, isomerization, and allied operations.

### Problems in Chemical Treating

Problems confronted by the petroleum industry vary with the type of product treated. They also vary with the changes in service requirements and specifications. Unfortunately specifications are not necessarily reflecting the service requirements and might be even contradictory. This is explained by the persistence of obsolete demands from products now used in modern machinery and by other reasons. It imposes a considerable burden on the conscientious refiner who is interested



**A sulfuric acid treating plant in a foreign refinery. Although in many cases not the most efficient reagent, sulfuric is still used to treat some types of products.**



**A treating unit with scrubber, left, and caustic regenerator, right, for refining high sulfur crude fractions.**

in supplying the public with the best product at a minimum cost to the consumer.

For many years hopes were expressed that refining and chemical treating problems could be simplified and the number of products manufactured from petroleum reduced from several thousands to a very few capable of meeting all the service requirements. These hopes are revived every time a new type of power mower is invented but have not yet been realized in practice. As a net result of such inventions new products have to be developed in addition to those already available on the market. This situation is not abnormal.

When new machinery is offered to the public mechanical difficulties encountered in making it practical overshadow the importance of proper selection of fuels and lubricants that have only minor effects on the engine performance as compared to other factors and are easily overlooked. However, with the improvements in engine construction the effects of the materials needed for operating it become apparent and as a result specifications for petroleum products are tightened instead of being relaxed. In a few instances this tightening of the specifications may go to such an extreme that they might be somewhat slackened eventually. Changes in jet fuel specifications during the last decade are an example of such fluctuations.

As the chemical treating problems are not the same for all petroleum products they must be discussed separately. Gasoline, kerosine, domestic fuel oils, lubricating oils, and waxes were chosen as the representative ones for this purpose.

### Gasoline

Gasolines form about one-half of the products manufactured by the refineries on a volumetric basis. The present trends of producing semi-synthetic or even synthetic gasolines of very high anti-knock qualities should continue in the future because of the importance of building up a large potential supply of high grade aviation fuels in time of emergency. Chemical treatment of these fuels is comparatively easy on account of their simplified chemical composition as compared to the gasolines of the past. In many instances removal of mercaptans represents one of the major problems in their subtractive refining.

Early processes were directed to the conversion of mercaptans to the disulfides but these reaction products are often more detrimental to oxidation stability and anti-knock properties of the gasolines than the original mercaptans while the improvement in odor can be often detected only by experienced persons on account of many substances of disagreeable odor present in the oil. Processes were developed for extracting mercaptans from petroleum fractions but their elimination was seldom complete. New processes of this type should appear on the market in the near future which will make possible their full separation from the oil without increasing expense but lowering the overall cost of gasoline manufacture due to improved lead susceptibility.

Many additives were developed, some of them very recently, for improving performance of gasolines. New oxidation inhibitors in the form of metal deactivators were discovered. Freezing of water in carburetors has been prevented by the addition of isopropyl alcohol. The use of phosphorus compounds for eliminating preignition difficulties in high compression engines and for preventing rapid spark-plug deterioration has been accepted in commercial practice. Other additives capable of improving some characteristics required from the present fuels or from the fuels of tomorrow may be expected to appear on the market. In some instances such additives might be useful for correcting the undesirable characteristics of additives already in use. Progress in tetraethyl fluid formulations is an example of this type.

Recent utilization of phosphorus compounds like tricresyl phosphate for improving the ignition qualities of motor gasolines is an interesting development showing that the maximum compression ratio justifiable for automotive engines of conventional design might have been reached. Addition of these phosphorus compounds may have little effect on the octane number of gasoline or even lower it slightly. The beneficial action of these compounds results from suppressing self-ignition of the air-fuel mixtures in high compression engines which begin to exhibit some properties of diesels.

This is not surprising because compression ratios as low as 15:1 might be employed for designing diesel engines and it is reasonable to expect that occasional high compression waves might occur even in engines of lower average



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compression ratios while some of the cylinder deposits might catalyze the reactions. These findings might lead to changes in engine design and to lowering of anti-knock requirements for automotive fuels that should benefit an average motorist. At least half of the driving is done in cities and towns where the benefits of expensive fuels are not as apparent as in cross-country driving.

### Kerosine

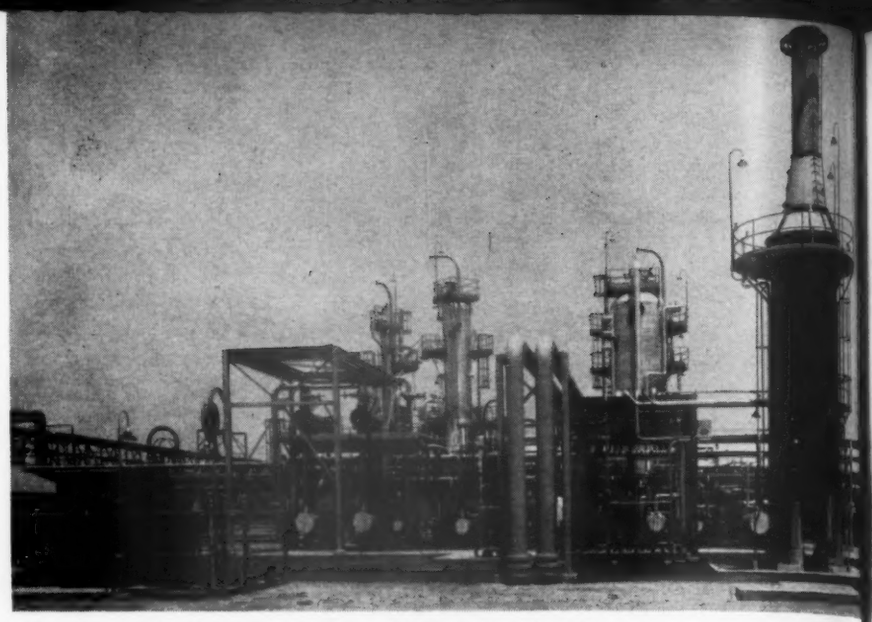
Kerosine, formerly the main petroleum product, constitutes now only about five per cent of the average refinery output even if its use as tractor fuel and range oil is included in the statistics. The old fashioned kerosine used as illuminating oil must be free of aromatic and unsaturated hydrocarbons and sulfur compounds. Their removal is usually accompanied by an improvement in product stability. It seems possible to improve kerosine burning characteristics by the use of additives but the declining demand for this product does not favor an extensive research on this important material of the past.

### Domestic Fuel Oils

Domestic fuels came into prominence with the progress in the oil burner design for home use and their production is almost half that of gasoline on a volumetric basis. They continue to offer an interesting chemical refining problem because of the low cost of the final product which is more expensive than coal as a heat producing substance but offers many advantages to the consumer by being a liquid fuel. The major problem encountered with these oils is sediment formation and to a certain extent odor. Both subtractive refining and additives are capable of improving the fuel oil quality.

The quantity of undesirable substances that must be removed for improving the properties of domestic fuels is very small. Sulfuric acid refining is satisfactory for this purpose, but the losses to sludge and the expense involved are disproportionately high. Additives now employed are dispersants rather than oxidation inhibitors. They are helpful for keeping sediment in suspension but not prevent its formation. These additives are mostly salts of metals and they might act as oxidation accelerators and not retarders as evidenced by the discoloration of the oil containing them in storage.

The increased rate of oxidation is small, however, in comparison with the ability of these additives to disperse the sludge formed. It seems feasible to improve stability of these oils with chemicals such as strong caustic solutions that extract only the deleterious substances at negligible sludge losses or to develop true oxidation inhibitors as a replacement for the present detergents.



**Solvent extraction is more and more widely used, as in this propane deasphalting lubricating oil refining unit.**

Development of such inhibitors presents an interesting problem to petroleum chemists. It is well known that the existing inhibitors are most active in well refined oils and that very many substances otherwise ineffective act as antioxidants if the oil is drastically refined. This indicates that inhibitors thus far developed are satisfactory only for certain types of hydrocarbons which form acidic substances on oxidation. Distillate fuel oils contain all types of hydrocarbons, and in all probability more than one inhibitor is needed to protect them from oxidation. Apparently no satisfactory inhibitors have yet been developed for hydrocarbons of the so-called aromatic type which are removed from the oil in the form of chemical sludge, and as a result detergents are employed for securing the overall oil stability. However, there seems to be no theoretical reason why true inhibitors for these hydrocarbons cannot be discovered eventually.

### Lubricating Oils

Chemical refining of lubricating oils is at the stage where no hydrocarbon constituents are lost to sludge in the course of refining but are recovered in their original state. Major efforts are concentrated now toward the development of additives.

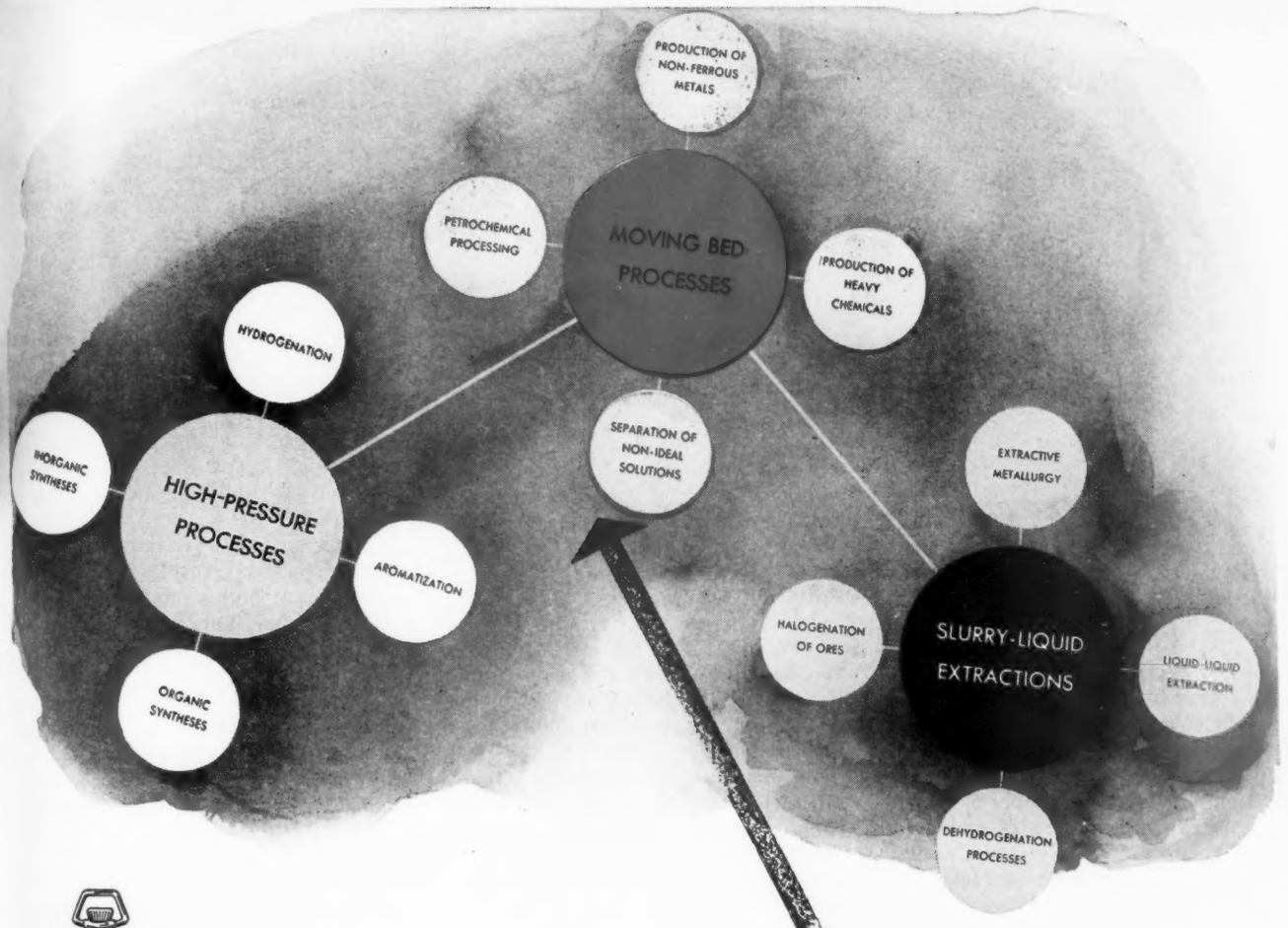
Progress along these lines, however, depends in many instances on the nature of hydrocarbon materials available. For instance, effectiveness of viscosity index improvers is much greater in low than in high viscosity oils, but the low viscosity oils have low flash points and distillation temperatures and they are quickly consumed by an engine. Future progress in viscosity index improvers depends on the development of an improved hydrocarbon vehicle more than on the discovery of a new type of additive.

On the other hand a considerable field for improvement is open in the search for detergents. Notwithstanding a considerable amount of work done in the laboratories for establishing the mechanism of their action little is yet known about it. Detergents used in motor oils apparently act as dispersants, oxidation promoters, and substances capable of changing hard carbon to fluffy carbon deposits in the combustion zone by interspersing metals between the carbon particles. It appears feasible that these actions might be separated and unifunctional additives of considerably greater efficiency developed. Although present motor oils are extremely efficient, development of new products capable of covering even wider temperature ranges than are now feasible may appear in the future as a result of further improvements in refining technique.

### Waxes

Waxes derived from petroleum continue to grow in industrial importance replacing the more expensive vegetable or animal waxes formerly employed almost exclusively. At the present time refiners assume that petroleum waxes are uniform substances consisting of normal paraffin hydrocarbons, although for many years it has been known that these waxes are made up of several hydrocarbon series having different properties and some of them possessing a cyclic structure. This explains to a great extent the differences in the nature of waxes derived from individual crude oils.

Solvents are capable of separating the hydrocarbons into series even if these series are fairly similar in some respects. This method will probably be employed for manufacturing petro-

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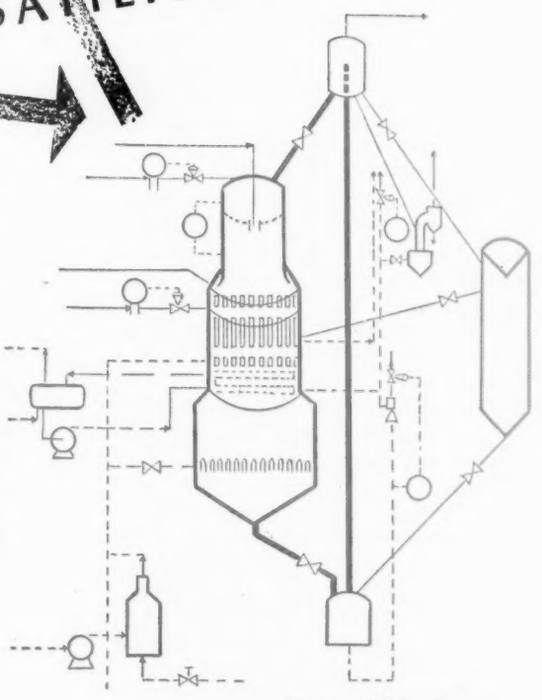

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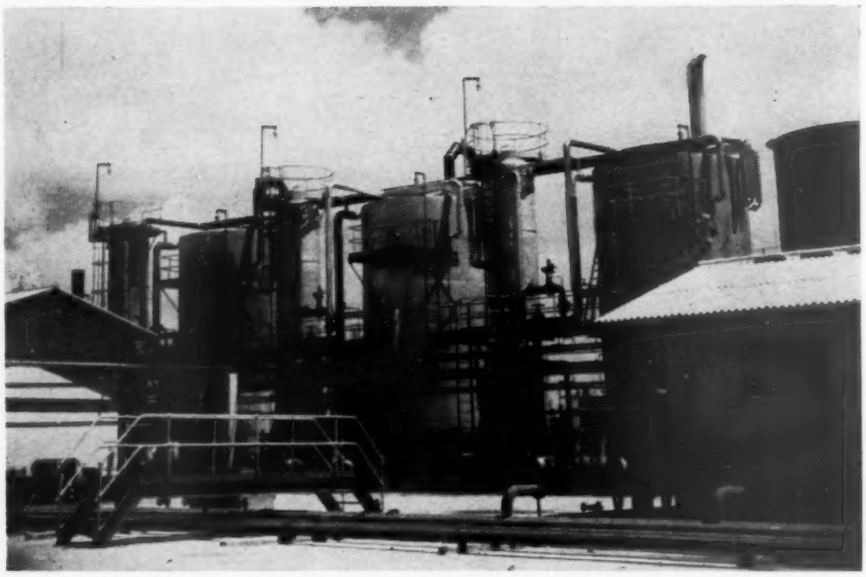

**A more modern doctor treating unit in Venezuela, still employed to meet customer's specifications for "sweet" gasoline.**

leum waves of improved characteristics in the near future and extend the field of their commercial application. Progress in petroleum wax manufacture will depend also to a very great extent on the ability to discover proper additives for improving properties of waxes to make them more universally applicable in all the numerous uses open for them.

### Evolution of Chemical Refining

Abandonment of the destructive subtractive refining methods in favor of the non-destructive methods and the use of additives opened new possibilities for manufacturing better and cheaper products from petroleum not yet fully realized. The use of solvents in combination with the synthetic and semi-synthetic manufacturing processes permits segregation of petroleum fractions into chemically similar groups simplifying many treating problems and inviting development of new methods for physically separating these groups still further. This eliminates introduction of newly formed substances into the oil which takes place if chemical reactions are utilized for the preparation of new products.

Similarities in the chemical composition of the resulting fractions has simplified selection and application of additives for improving their quality but little work of fundamental nature has yet been recorded along these lines. It may be expected that future investigations will be directed toward elucidation of these problems by substituting a scientific approach for present empirical approach to petroleum refining.

Solvents and chemicals used in petroleum refining are not ideal and their properties like oxidation stability, corrosiveness, or viscosity characteristics can be improved by the use of additives. Little has been done yet in this connection but progress along these lines might be expected in the none too distant future. It is also likely that a satisfactory solvent will be found for commercial use which would have a boiling point sufficiently high to permit its handling in atmospheric equipment but lower than those of the present solvents used for lubricating oil extractions so as to allow its easy separation by distillation from the comparatively low boiling petroleum fractions. Another approach to the same problem already realized in one of the recently developed processes for separating aromatic hydrocarbons from the low boiling distillates involves the use of very high boiling solvents from which the oil is distilled.

### Chemical Treating Costs

Since the early days of petroleum industry chemical refining was regarded as an unavoidable nuisance and its cost was kept at a minimum even if a small additional expense offered overall savings in petroleum processing. Obsolete equipment was retained, and still is by many plants, and more than once new processes chemically less satisfactory but better worked out mechanically than the old processes were adopted to the eventual disappointment of their users. These unnecessary expenses were caused by the absence of appreciation by the many old timers of the savings that can be effected by systematic research conducted by competent chemists and engineers in the field of petroleum industry. Additives appeared to offer an easy panacea for all the difficulties and refiners began using them indiscriminately and often disregarding their cost.

In many instances attempts are made to improve the product quality by increasing the quantities of additives employed without realizing that after a certain optimum is reached the action of the additives may reverse in the wrong direction or they may harm some other properties of an oil. To alleviate these difficulties new additives are used to correct the action of additives already present until the oil becomes a complex mixture of chemicals neutralizing each other with the hydrocarbons in the background. This condition may be explained at least partially by the gradual shift of research along these lines to the chemical companies instead of maintaining it within the petroleum companies where these investigations should be conducted. It is to be hoped that this shift might reverse in the more or less near future and result in improved petroleum products at a lower cost both to the refiner and to the consumer. Otherwise, the cost of chemical refining will continue to rise indefinitely.

Petroleum refining is not only a peacetime but also a war industry. The present unstable political situation requires that a certain balance be maintained between these two often conflicting aims. Huge quantities of petroleum products passing military specifications must be available immediately after an emergency arises. Even a brief delay in meeting this demand may lead to a catastrophe. Spare crude oil production and refining capacity is only a partial answer to this problem.

The basic difference in military and civil requirements is the stress on performance or economic utilization of the materials, respectively. These two demands seldom coincide. Sometimes machinery showing exceptional performance might be utilized by the civilians but it will stay idle in wartime when supplies of the required fuels and lubricants are diverted to the army. As an alternative civilians may be compelled to use higher grade and more expensive materials than are required by engines that can be operated on the inferior grades of petroleum products in an emergency. This can be corrected only partially by building spare factories for manufacturing some specific additives for the wartime needs.

Whatever the best economic solution of the problem might be, it can be done only at an additional expense borne by the car owner or the taxpayer who happen to be identical in this case.

It will contribute, however, directly or indirectly to an increase in the manufacturing costs including the cost of chemical refining, which will be greater, because of the necessity for military alertness, than the savings that can be expected from improvements in refining technology. * * *

**Jetty construction at Kwinana, December 1953, to supply Australia with harbor.** *—Courtesy, Anglo-Iranian Oil Co.*

# Australian Refining To Be Self-Sufficient

*From supplying 15 per cent of the country's needs in 1953, some 80 per cent will be refined locally by 1956*

H. BOWDEN FLETCHER*

EVER since it was settled and since petroleum products became an essential part of transport Australia has depended on overseas refineries for its supplies and even now it only produces 15 per cent of its refined product requirements. A change is rapidly coming over the scene, however, and the present output of 380,000 tons, 3,190,000 bbl, of motor spirit, 120,000 tons, 900,000 bbl, of gas and diesel oil, 300,000 tons, 1,980,000 bbl, of fuel oil and 25,000 tons, 177,500 bbl, of lubricating oils annually will be rapidly stepped up until in 1956 80 per cent of the then estimated requirements will be refined locally.

The first plant to come into operation under the large expansion program is that of Shell at Geelong Victoria on March 18 this year with a throughput of 1,090,000 tons, 8,000,000 bbl, per annum and this will be followed by the Standard Vacuum plant at Altona Victoria in November this year with a throughput of 1,000,000 tons, 7,300,000 bbl.

Briefly, at the time of writing, the position is as follows:

**Shell Company** has a plant at Clyde NSW with four separate sections with capacities and productions as follows:

1. *Topping plant with a capacity of 34,000 tons, 248,000 bbl, per month producing 22,300 tons, 187,000 bbl, of gasoline, 3000 tons, 122,500 bbl of diesel oil and 8,500 tons, 56,000 bbl, of fuel oil.*
2. *Boiling point solvent plant with a capacity of 500 tons, 4100 bbl, per month and producing to capacity.*
3. *Bitumen plant with a capacity of 5000 tons, 32,000 bbl, per month producing 500 tons, 3750 bbl, of gas oil, 300 tons, 2350 bbl, of distillate and 3000 tons, 19,000 bbl, of bitumen per month.*
4. *LVI plant with a capacity of 600 tons, 4300 bbl, per month and producing 550 tons, 4000 bbl, lubricating oils per month.*

**EXCLUSIVE**

The company has a very extensive scheme of plant extensions under consideration for this location but, at the moment, nothing is available for publication. It is intended, however, to make the Clyde plant the key unit in the company's future refining program.

At Geelong in Victoria this company has erected a new distillation refinery with a capacity of 1,090,000 tons, 8,000,000 bbl, per annum and this will be officially opened by the Governor General Sir William Slim on March 18 of this year. Plans have already been announced, however, for the addition of a cracking plant, in conjunction, to be completed by the middle of 1955 with an intake of 650,000 tons, 4,750,000 bbl, per annum thus bringing the total capacity of the plant to about 1,750,000 tons, 12,775,000 bbl. This extension will include an increase in the tankage holding capacity to 60 with an

*Australian correspondent, UTPS.



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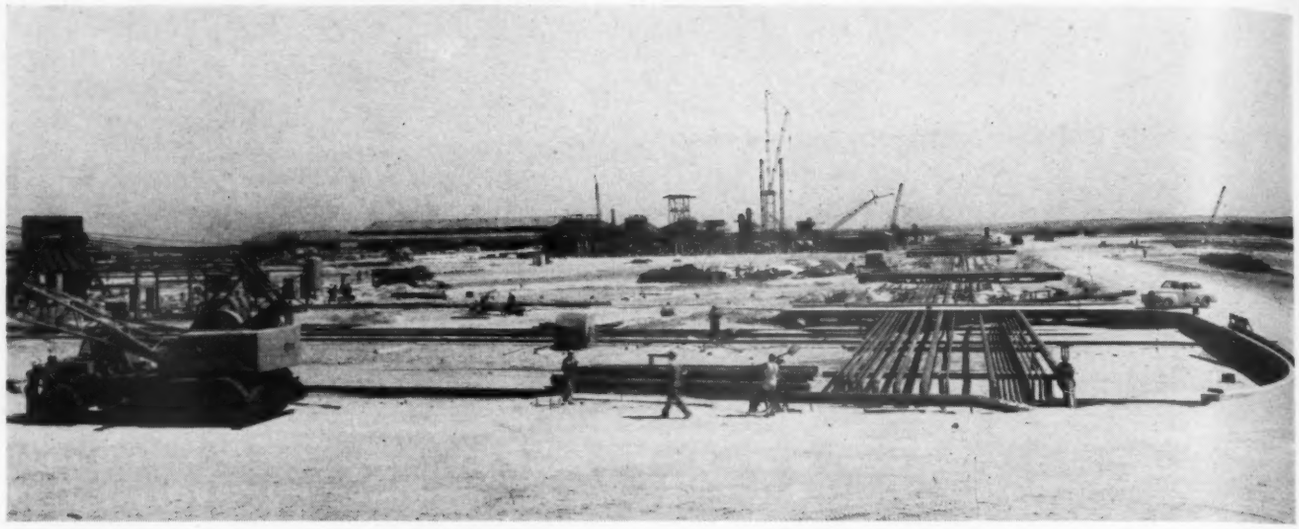


**View of Kwinana refinery project, December 1953. The guy derrick is placed in the location where the catalytic cracker is under construction.**

aggregate of 400,000 tons, 2,900,000 bbl.

It is interesting to note that the crudes for this plant will come from the Middle East, Seria, and British Borneo fields all of which are in the sterling area.

**Vacuum Oil Company** has a plant at Altona Victoria for the production of lubricating oils with a capacity of 80,000 tons, 570,000 bbl, per annum and production has reached within a fraction of that figure. Expansion plans now being completed include a distillation and cracking plant with a capacity of 1,000,000 tons, 7,500,000 bbl, per annum which, as previously mentioned, is expected to commence production in November this year (1954). Full details of this plant were given in a previous article and the output is expected to be motor spirit 10,000 bbl per day, lighting kerosine 1400 bbl per day, power kerosine 1000 bbl per day, diesel fuel 1500 bbl per day, industrial and bunker fuel 3000 bbl per day.

**Bitumen and Oil Refineries** has a bitumen production plant on Botany Bay, Sydney, with a capacity of 240,000 tons, 1,500,000 bbl, per annum but a breakdown of the output is not available, having been refused by the company. It is generally known to be efficient and handling close to its rated output. The company, in conjunction with other interests, has floated a new company for the production of chemicals from the byproducts and also intends to establish a new bitumen plant in Queensland with an output of about 3000 tons per month.

**Commonwealth Oil Refineries** has a plant at Laverton Victoria with a capacity of 140,000 tons, 1,000,000 bbl, per annum but this has been idle since the end of the war, having been taken over by the Anglo-Iranian Oil Company, it is not proposed to bring it back into production but its final allocation has not yet been decided upon.

**Caltex Oil Australia Ltd.** Under the control of its subsidiary company Australian Oil Refining Ltd., a new refinery has been commenced on the shores of Botany Bay, Kurnell, Sydney. This will be an ultra-modern distillation and cracking plant comprising

1. *A flexible two-stage distillation unit.*
2. *Fluid catalytic cracking unit with gas recovery facilities.*
3. *A propane Secarbobisation unit for preparation of a portion of the fluid unit charge stock.*
4. *Necessary treating, inhibiting, and blending facilities to ensure products of highest quality.*

Intake of the plant will be 22,000 bbl per day and the scheduled output is to be

| | |
|---|---|
| Gasoline | 12,300 bbl per day |
| Illuminating kerosine | 400 bbl per day |
| Automotive diesel oil | 1,600 bbl per day |
| Industrial diesel oil | 800 bbl per day |
| Bunker fuel oil | 4,100 bbl per day |

Erected on a site of 400 acres, work is proceeding well on the planned schedule. The 12-mile road of access has been completed and was, in fact, opened for traffic on June 20, 1953, 12 weeks from the date of commencement. A 12-in. water main from the existing mains at Cronulla has also been constructed to the site, which has all been levelled by the removal of 540,000 cu yd of sand.

Dredging of the channel in Botany Bay, for the oil tankers, involving the removal of 1,300,000 cu yd of material is well under way and about 20 per cent has been shifted. All temporary construction facilities have been erected while in addition the pouring of the unit foundation is in progress. Pile driving has started for the jetty and work has commenced on the erection of the tank farm. The plant is scheduled for operation on July 1, 1955.

**Anglo-Iranian Company.** The 3,000,000 ton, 22,000,000 bbl, plant being erected at Kwinana, West Australia, by the subsidiary Australasian Petroleum refinery is expected to be in full production by the middle of 1955 and the latest report from the site indicates that the position is as follows:

1. *Refinery units.* Except in the case of the platformer, the foundations of which are being laid, all foundation work for the main units has been completed. Work now continues on the furnaces, pipe supports and pumps and the setting up of a number of drums and towers.

2. *Services.* Foundations for the steam generating plant are practically complete and steel is being erected for the boilers. Sheet piling is being driven for the cooling water intake and a number of substations for the electric distribution have been erected.

3. *Refining Buildings.* Steelwork for the large maintenance workshops has been erected and the building roofed and glassed. Brickwork is being laid and concrete for machine foundations poured. Brick buildings being erected by sub contractors include the process and maintenance offices, medical building, time office and seaman's mess, fire station and a smaller building have not quite reached this stage.

4. *Tankage.* The laying of bottoms and shell plate has been started on at least 30 of the storage tanks and on four of the 5,500,000 gal crude tanks the eighth tier has been set. The majority of the bunds have been laid.

5. *Oil Jetty.* Box steel piles have been driven for the whole of the 1000 ft

shore arm and for most of the 1800 ft trunkway. Over 500 pre-cast concrete units including longitudinal and transverse beams, trestles skirt units and road slabs have been poured and many of them positioned.

6. *Pipe Lines.* The stringing and welding of pipe and installation of pre-cast sleepers is continuing steadily. Grading and ditching has started on the 17 mile pipe line route to Freemantle.

Thus it will be seen that all the new refining units are being constructed in accordance with the planned program and in 1956 when they are all operating Australia will produce approximately 80 per cent of its petroleum requirements.

Production of refined products in the last full year, for which figures are available, (1952), were as follows:

| | |
|---|---|
| Motor spirit | 95,100,000 gal |
| Kerosine | 500,000 gal |
| Gas and diesel oil | 135,000 tons (1,000,000 bbl) |
| Furnace oil | 370,500 tons (2,780,000 bbl) |
| Asphalt | 94,500 tons (600,000 bbl) |
| Lubricating oil | 6,200,000 gal |
| Consumption for the same year was;— | |
| Motor spirit | 669,764,000 gal |
| Aviation spirit | 38,274,000 gal |
| Power kerosine | 72,871,000 gal |
| Light kerosine | 47,347,000 gal |
| Gas oil | 328,110 tons (2,460,000 bbl) |
| Diesel oil | 582,390 tons (4,370,000 bbl) |
| Furnace oils | 519,750 tons (4,000,000 bbl) |

As 1956 will be the first year of full production from all the new plants the anticipated production figures are as follows:

| | Production long tons | Consumption long tons |
|---|---|---|
| Motor spirit | 2,590,000 (21,750,000 bbl) | 3,200,000 (26,900,000 bbl) |
| Kerosine | 220,000 (1,750,000 bbl) | 550,000 (4,350,000 bbl) |
| Distillate and diesel fuel | 1,295,000 (9,700,000 bbl) | 1,850,000 (13,900,000 bbl) |
| Fuel oil | 2,041,000 (13,000,000 bbl) | 1,700,000 (10,900,000 bbl) |
| Other products | 400,000 | 600,000 |
| | 6,646,000 | 7,900,000 |

It is possible, however, that these figures do not include the new addition to the Shell plant at Geelong of 650,000 tons, 4,750,000 bbl, which was announced about the time these figures were prepared.

### Search for Oil in Australia

Hundreds of millions of dollars have been spent in Australia and its neighboring territories in the search for oil without any signs of success until just recently but the discovery of oil in West Australia by West Australian Petroleum Company in its first test bore has given great incentive and encouragement to all the organizations engaged in the search.

In this trial hole between a depth of 3605 ft and 3620 ft, a 24-hour test run through a half-inch choke produced 600 bbl of crude. This horizon was then sealed off and drilling continued and is now round the 6000 ft mark but no further traces of oil have been found. It is proposed to go to 12,000 ft on this site and further drilling plant has arrived to commence several additional holes on carefully selected sites. It might be mentioned that characteristics of the crude oil recovered indicate that it came through restricted channels from some distance.

As a result of this discovery six additional companies have been granted exploration licenses in West Australia and the original capital asked for by them was subscribed within 24 hours of the subscription lists opening. Australian investors went oil-mad for some weeks. In fact they still are and new floats are finding no trouble in raising capital in spite of the fact that their exploration licenses are in areas that are thousands of miles from the West Australian strike.

The North West Basin is naturally regarded as the best risk in the oil search but even it has certain doubtful features which are stated to be:

1. It has not the United States' background and suffers from the fact that the Tertiary sedimentaries are comparatively thin (maximum 1000 ft) and no sign of oil has been observed in them, in bore holes, or in major well drilling now taking place. As the Tertiaries are responsible for half the world's oil production their absence, alone, reduces the chances of finding oil in quantity probably by half.

2. Absence of regionally porous and permeable beds within the geological column through which the drill is anticipated to pass. The statement that the sand from which the showing of oil was obtained is very wide spread is against the chances of unbroken permeability as a much heavier flow of oil, under pressure, would have been expected in such a case.

On general grounds, it is considered that, on the mainland of Australia, the prospects of finding oil are restricted to the two geosynclines that run parallel to the Eastern and Western shores of the continent. The eastern of Tasman geosyncline offers little hope, as Permian and younger strata have been studied intensely, either at the surface or in mines and bores and have given no indication of the existence of possible source or reservoir beds on any commercial scale. Beds older than Permian have been so severely metamorphosed by mountain building movements and their accompanying widespread igneous intrusions, that any substantial pools of oil, which may have been contained, will have been dispersed and lost. Small but noncommercial production has been obtained from the Tertiary (Lakes Entrance, Victoria) and Triassic (Roma, Queensland) but this oil is believed, by some experts, to be derived from carbonaceous shales by destructive distillation. Shell Company, at a cost of $2,500,000, made a very thorough examination of the Roma, Queensland, possibilities over a three-year period, culminating in the sinking of a test bore at a carefully selected site. This was sunk to 4634 ft through Permian beds to basement and not a trace of oil or even extensive strata of sufficient porosity or permeability to act as reservoirs were found.

This result has not stopped activity as Associated Roma Oilfields is still actively drilling in the area and new companies have been formed to explore new areas in the same state. Hope springs eternal in some bosoms!

Thus the best hope for commercial oil in Australia is the North West Basin where indications have already been found and time alone will tell whether it will be found in sufficient quantities to justify full exploitation.

It is generally considered, however, that the Territory of Papua and New Guinea is the best hope for a real oil find and very extensive test drilling is now being carried out there by Australian Petroleum Company. Several holes have been sunk and several others are being sunk simultaneously at the present time. Many millions of dollars have already been expended and the companies associated with the operating unit, are prepared to spend many more millions before giving up the ghost. Island Exploration is also drilling and several other organizations are expected to join in the search. The main company has drilling plant capable of going to 20,000 ft and the work is being supervised by the best world experts.

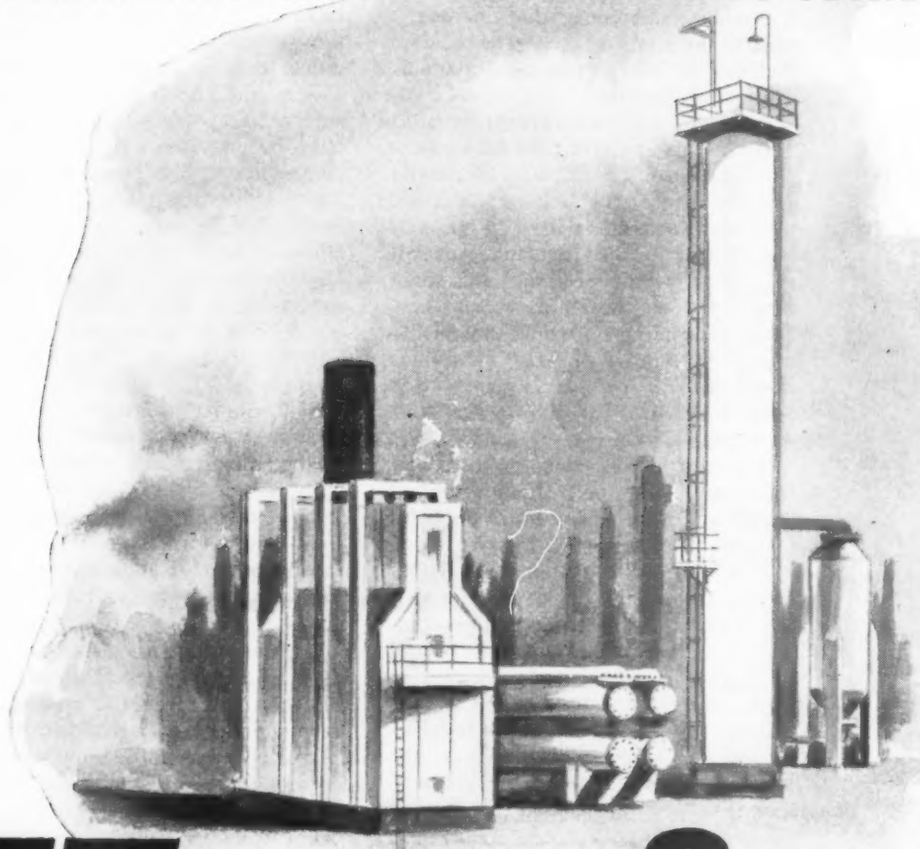
Whether Australia eventually finds oil in commercial quantities is still in the lap of the gods, however. If oil is found it will be the greatest boon to Australia since the discovery of gold and would make it independent of overseas sources, always in danger of cutting in times of war. Oil is Australia's life line and production of crude within the continent would solve many problems. * * *

### AIOC Refineries

Lubricating oils are now being produced at the Porto Marghera refinery near Venice, Italy, by Anglo-Iranian Oil Company. Completion of the units will enable the refinery to produce 107,000 bbl of lube oil annually.

A new distillation unit is nearly completed at the BP Hamburg refinery, which will raise its capacity from 14,000 bbl-a-day to nearly 25,000 bbl-a-day. A 5000 bbl-a-day platformer for high grade motor fuel components is also being built at Hamburg.

ANOTHER IMPORTANT CONTRIBUTION TO PETROLEUM PROGRESS



# Unifi



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# *A New Catalytic Refining Process to Purify Petroleum Distillates*

Universal Oil Products Company is pleased to announce that the UNIFINING process is now available to the petroleum refining industry, and a refiner may secure the benefits of the combined techniques and patent rights of both Universal Oil Products Company and Union Oil Company of California through a single licensing arrangement.

The process uses a cobalt-molybdenum type catalyst to react hydrogen with petroleum distillates, saturating the olefinic hydrocarbons and removing sulfur, nitrogen, oxygen, and other impurities to the degree desired by the refiner.

Excess hydrogen from a UOP Platformer provides an excellent and economical source of hydrogen for the Unifining unit.

**i n i n g**

Unifining is particularly advantageous for pretreating certain types of feed stocks prior to processing in a UOP Platformer. By using Unifining in combination with a Platforming unit, the refiner will find that engineering advantages accrue which will be reflected in lower costs to him.

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**FIG. 1. Control panel in new lubricating grease plant of British American Oil Company, Clarkson, Ontario.**
*—Photos on these two pages courtesy, British American, C. F. Nofsinger, and NLGI Spokesman.*

# Recent Manufacture and Application Advances in Lubricating Greases

*New fillers, both organic and inorganic, used for improved greases; heat-resistant non-hydrocarbon fluids also useful*

**CHARLES J. BONER**

THE lubricating grease industry finds itself, like many other industries, in the situation described by Alice in Wonderland of having to run just twice as fast to stay where it is. Some idea of how manufacturers and distributors of lubricating greases are not only holding their own but also forging ahead can be judged by the following.

First, advances in equipment and manufacturing methods will be described. Next, advances in the thickeners used in such lubricants will receive attention, followed by mention of advances in lubricating fluids. Finally, characteristics of finished lubricating greases and also application of such products will be considered.

### Equipment General

Up to date equipment and arrangement of the same for the most efficient manufacture of lubricating greases is exemplified by the newest plant for this purpose, completed and put in operation in April 1953 by the British American Oil Company, at its Clarkson refinery near Toronto, Canada. Although certain descriptions of this plant have been previously published,[4,5] specific use or arrangement of equipment is worthy of note.

### Operation Control

The control panel, shown in Fig. 1, is situated on the second or operating floor. Here recording temperature controllers permit the operator to control remotely the temperatures of liquid fats or oils being charged through weigh tanks to any one of the pieces of processing equipment. Although weigh tanks and scales are provided on the top floor of the building housing the manufacturing equipment, the flow of process materials from storage to weigh tanks is regulated by the operator at the control board. For this purpose, hand-operated valves are provided. Likewise, remote scale dials are placed on the second or operating floor as shown in Fig. 2. These remote dials are in view of the control panel.

Piping at the weigh tanks is so arranged that fats or oils can be returned to storage if necessary. Further, a high-level signal and an alarm as well as an emergency overflow to a sump tank is provided at each weigh tank.

Other instruments on the control panel include a recording temperature controller that permits automatic adjustment of the temperature of the circulating heating oil. A multipoint potentiometer permits observation of the temperature at various points of the processing equipment, and a four-point recorder is connected to a contactor (the saponification vessel) and a kettle used in conjunction.

### Storage and Processing Heating

The fat and fatty acid storage tanks are warmed by means of steam heating coils on the outside of the conical bottoms of the tanks. Insulation is also

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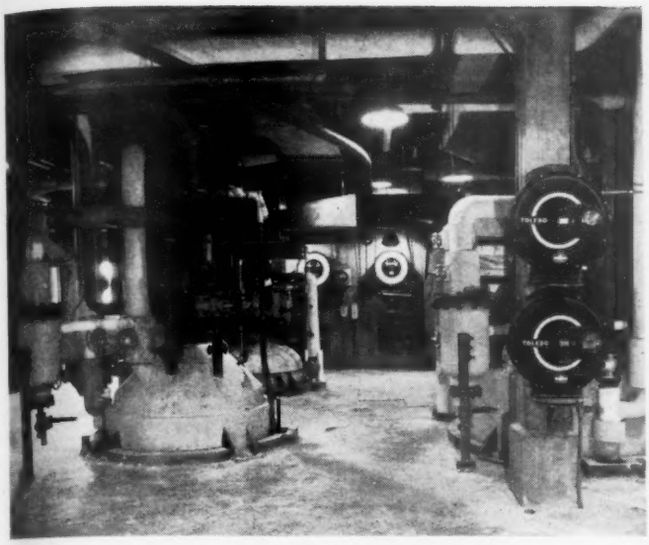

FIG. 2. View of second (operating) floor of British American's Clarkson plant.

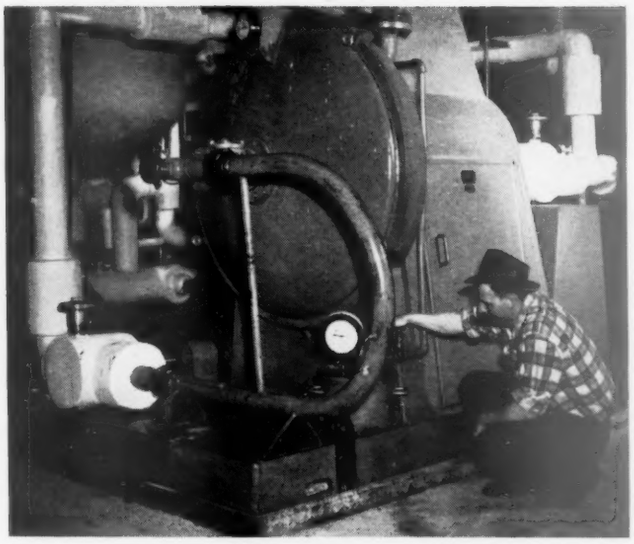

FIG. 3. Deaerator-dehydrator installed in British American plant.

provided so that the contents can be kept at 120 to 150 F. Side-entering mixers are provided in such tanks.

The processing vessels, of 6000 to 15,000-lb capacity, are jacketed and heat is provided by circulating 200 to 300 gpm of hot oil through the jackets. This oil is heated to 450 to 500 F by an automatically controlled gas-fired furnace.

Whereas vessels in which steam is used as the heating medium normally use water for cooling, the British American plant employs cold oil for this purpose.

### Saponification Equipment

This plant, like most of the facilities for the manufacture of lubricating greases that have been installed in the last few years, makes use of a "Stratco Contactor" for saponification. Such equipment permits complete and rapid reaction of fats and alkalies employed to make soaps and thus effects economies in both labor and materials.

### Dehydrating

In order to accelerate dehydration of batches of lubricating greases, vacuum is provided on some of the processing vessels. This vacuum is maintained by a steam jet ejector. By use of this procedure in connection with a "Stratco Contactor" the time for dehydration is reduced materially over that which is required when this step takes place in heated open kettles.

Final dehydration, as well as deaeration, may be accomplished by the Deaerator-Dehydrator shown in Fig. 3. It will be noted that this unit is much larger in diameter than "Cornell Homogenizers," which have been in use for this purpose for a number of years. This results in a decrease in processing time due to a larger throughput.

### Milling

A milling step is becoming increasinly important in the manufacture of lubricating greases. For example in the British American plant each finished batch of lubricant is passed through a colloid mill. Such treatment improves the mechanical stability and storage characteristics of the lubricating grease.

An example of the type of equipment used for such purpose is the portable "Morehouse" milling and deaerating unit, powered with a 40 hp motor, and shown in Fig. 4. This equipment, which has a capacity of 25,000 lb per hour, can be disconnected and moved quickly and easily to take the discharge from any of several lubricating grease processing vessels.

In the case of the newer non-soap thickeners for lubricating oils, some type of milling is essential in dispersing the bodying agent. A suggested flow diagram for processing one such thickener, "Bentone 34," is shown in Fig. 5. Although the manufacture of a satisfactory lubricating grease with such a thickener may not be as simple as the diagram indicates it does show the necessity for the use of a mill.

Most of the milling devices in use for processing lubricating greases consist of a rotor set very close (from .001 to .003 of an inch) to a stator. As the rotor is driven at high speed a mixture of thickener and fluid is subjected to mechanical shear. This is the construction of the "Tri-Homo Disperser" shown in Fig. 6. Here laboratory equipment is being used to process "Bentone 34" into a lubricating grease.

For one type of non-soap thickener, namely "Permagel" shear by extrusion under pressure and high temperature has been found most satisfactory. A laboratory arrangement for this purpose is shown in Fig. 7. Here a "Manton-Gaulin Homogenizer" is used as the dispersion or milling device. Pressures of 5000 to 6000 psig can be obtained as the mixture, heated to 225 to 250 F, is forced out through tapered valves. In some cases two-stage valves are used.

A simpler arrangement, which apparently gives the same type of shear, is described by Fitzsimmons *et al*[1] when a method for processing mixtures of copper phthalocyanine and lubricating fluids is explained. One method of forming the lubricant consists of: 1, slurrying the previously heated pigment and the fluid; 2, cycling the slurry through a paint mill; and 3, heating the milled product to 225 C. It was found that the above three steps could be replaced by cycling the slurry


**The Author**

Charles J. Boner, chief research chemist, Battenfeld Grease and Oil Corporation, is known wherever lubricating greases, their manufacture or their application is known or studied. He has been engaged in manufacture and research on greases for the last 27 years, is a member of the American Chemical Society, American Society of Lubrication Engineers, and the Technical Committee of the National Lubricating Grease Institute (NLGI), also of the Committee D-2 of the ASTM.

His more than a quarter-century of research has resulted in a forthcoming book, "Manufacture and Application of Lubricating Greases," which will be off the press in the fall of 1954, by Reinhold Publishing Corporation.

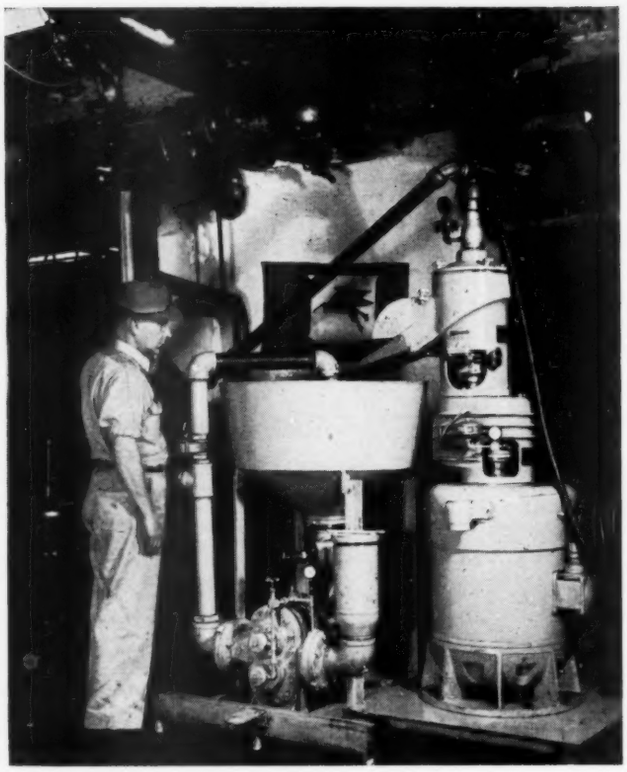

**FIG. 4. High-Capacity Morehouse mill and deaerator in service.**
*— Courtesy, General Petroleum Corp., and NLGI Spokesman.*

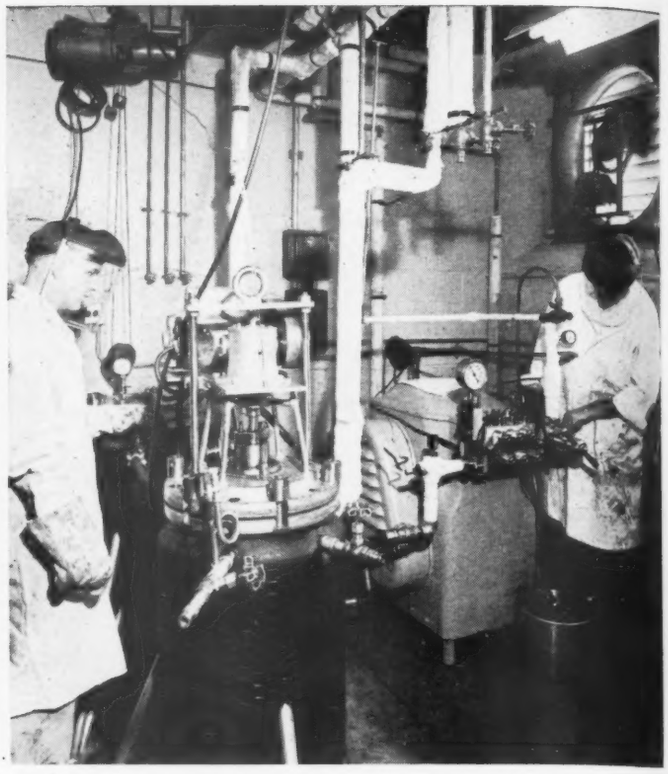

**FIG. 7. Processing equipment for development work in manufacture of lubricating greases from Permagel.**
*— Courtesy, Attapulgus Minerals and Chemical Corp.*

in a closed system through a pressure relief valve set to open at 500 to 700 psi.

### Types of Thickeners

Inasmuch as non-soap thickeners are the newest bodying agents for lubricating fluids, they will receive first mention. Such placement should not be construed as wholly endorsing such materials in place of soap thickeners. Those bodying agents can be classified as those of organic origin or those of inorganic origin.

One type of the former is phthalocyanine pigments, of which copper phthalocyanine is preferable for the manufacture of lubricating greases. Such thickening agents have been suggested for use in lubricants that are employed for application to anti-friction bearings operating at temperatures of 250 to 300 C for restricted periods. These pigments are stable at temperatures much above such points and in addition do not act as catalysts toward oxidation of lubricating fluids. The cost of such thickeners will probably deter their use except for special purposes. Further, the conditions under which most lubricating greases are employed do not necessitate the use of bodying agents of such high temperature stability.

Another class of organic thickeners, which is stable at temperatures up to 600 F, consist of substituted ureas. No details have been given[7] of the processing of such thickeners but it can be expected that thermal means, as well as milling with the lubricating fluid, is necessary in order to form satisfactory lubricating greases.

The thickeners of inorganic origin, which are being used in lubricating greases, consist largely of two types. The first is a product which has the nature of a gel at one stage of its manufacture. Silica gel is an example of this class of bodying agent. The particles of silica resulting from the method of formation are said to be about 50 millimicrons in diameter. These particles may be aggregated into clumps of 3 to 5 microns in size. Due to this fine particle size the silica is not abrasive in the finished lubricating greases.

Untreated silica gel, however, does have one particular defect in that it is not resistant to water. To correct this defect, the thickener must be coated with a water repellant material. Some manufacturers of silica for thickening lubricating fluids so modify their product before it is sold to the grease-maker but others leave this step to him.

Processing of silica gel thickened lubricating greases can be accomplished by simple mixing but a more satisfactory finished product is obtained if milling follows mixing. The characteristics of this type of product will differ with variations in the lubricating fluids and the additives used.

A type of silica that is being introduced by du Pont has been made water repellant and oil wettable by esterifying the surface of finely divided silica. As the dusting and low density of silica gels make handling somewhat difficult, this silica, known as "PL-171 Fine Silica," is compressed into granules of higher density with less tendency to dust than the original. A micrograph of this type of silica is shown in Fig. 8.

The second general type of non-soap

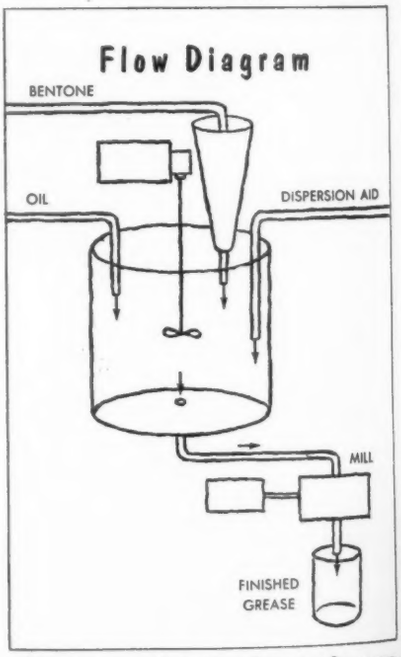


**FIG. 5. Suggested flow diagram for processing Bentone 34 into a lubricating grease.** *— Courtesy, National Lead Co.— Baroid Sales Div.*

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thickener of inorganic origin consists of modified clays. One such product is formed by reacting bentonite with an organic amine. Such chemical modification makes the bodying agent water repellent.

As noted previously, a requisite for processing a mixture of the above thickener with oil is passage through a mill. This alone is not ordinarily sufficient as certain polar liquids are an aid in obtaining proper dispersion of the thickener. Heat however is not necessary in processing organophilic bentonite.

Another clay base thickener consists of a colloidal type of fullers earth. This likewise requires a surface active agent to confer water repellency. The processing in this case, (see Fig. 7) consists of mixing the clay, the surface-active agents and mineral oil, heating to 220-250 F and then extruding under a pressure in the range of 5000 to 6000 psig. This permits volatilization of some of the moisture contained in the clay at the time the additives become attached to the surface of the clay particles.

In the case of both of these thickeners the particle size is such that practically no wear occurs when they are a component of lubricating greases. The derivatives of bentonite, "Bentone," is said to be in the form of platelets. The form of the colloidal fullers earth. "Permagel," is shown in Fig. 9. It is seen that this thickener is needle-shaped.

Although not entirely new, the status of lithium soaps as thickeners in lubricating greases is worthy of note. In Fig. 10 the production of this type of lubricant is shown for the past few years and projected ahead two years. This projection is possible with reasonable accuracy because shortage of lithium compounds has held back certain companies who desire to distribute such a lubricating grease. As increasing amounts of lithium hydroxide become available, these people will enter the field. The production of lithium-base lubricating greases started during World War II because of the need of proper aircraft lubricants. This production has risen from nothing to the present substantial amount in a little over ten years.

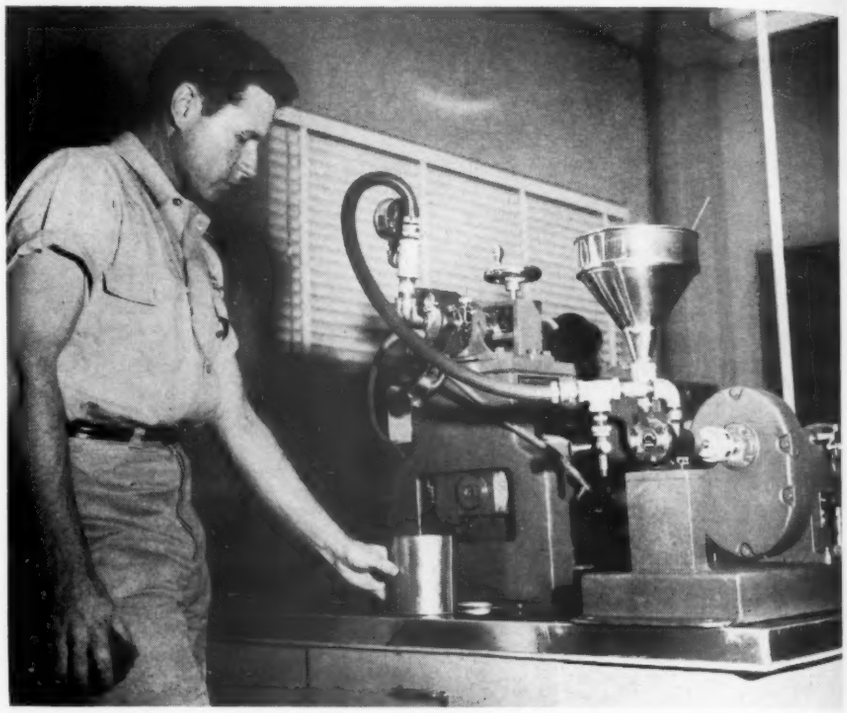

**FIG. 6. Tri-Home disperser employed for milling Bentone-thickened lubricating fluids.** *— Courtesy, National Lead Co. — Baroid Sales Div.*

Development of lithium-base lubricating greases has been distinctly an American advancement. At present, there are some 36 individual plants producing lithium-base lubricating greases in the United States and Canada. About a half-dozen plants produce such lubricants in the rest of the world.

### Lubricating Fluids

Lubricating oils derived from petroleum are and will continue to be the principle fluids used in lubricating greases, except for special applications. The greatest change in such oils is a gradual increase in the viscosity index (VI). Reasons for the use of higher VI oils are that the pumpability of the lubricating greases of which they are a part is improved and, on an average, they give lubricants of better oxidation resistance. Further a smaller proportional gallonage of conventional oils are becoming available every year.

A class of synthetic lubricating fluids known as diesters have been employed, largely in lubricating greases purchased by the government. The value of products containing such a fluid is that they are usable over a much wider temperature range than are lubricating greases containing mineral oils of a

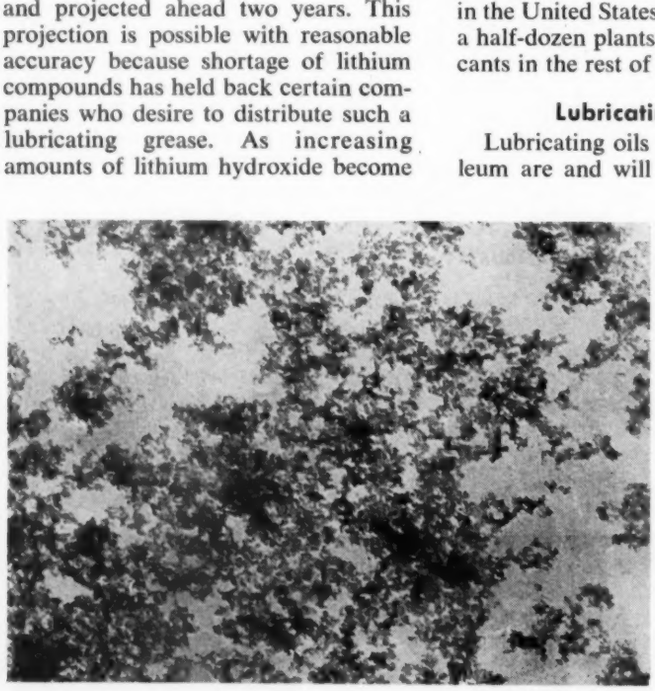

**FIG. 8. Micrograph of PL-171 fine silica — magnification about 70,000 diameters.** *— Courtesy, Pet. Chem. Div. du Pont.*

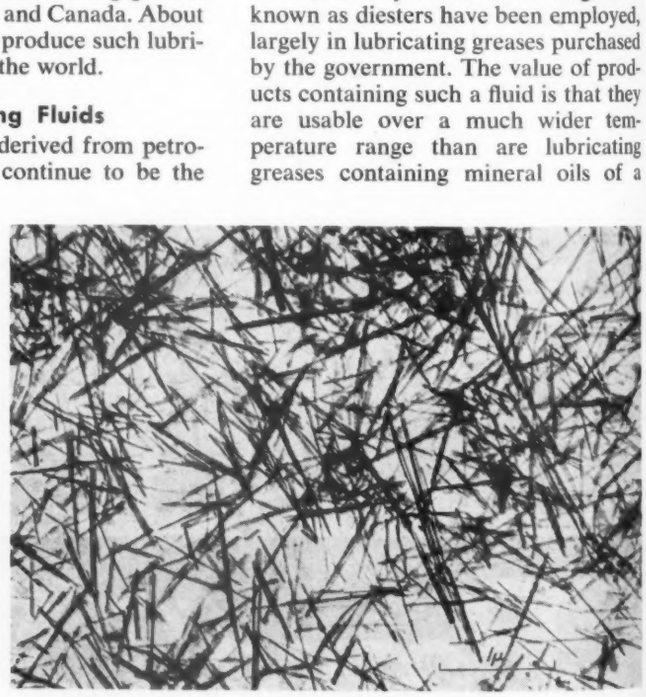

**FIG. 9. Micrograph of Permagel thickener for lubricating fluids.** *— Courtesy, Attapulgus Minerals and Chemical Corp.*

comparable viscosity. The diester having the widest use has been di-2-ethylhexyl sebacate, which is priced in the order of about 50 cents per pound. Indications are that suitable synthetic fluids will be available at somewhat lower prices. Thus one producer of fatty acids has put in operation a process whereby a comparable ester, the azelate, is produced at a cost of several cents a pound less. Also it has been suggested[3] that diesters made from pinic acid would be satisfactory lubricants over a wide temperature range and yet might be produced at a still lower cost.

Fluorocarbon lubricants should be mentioned also. These products, some of which sell for about $300 per gallon, are of value because they are inert to most oxidizing and corrosive chemicals, such as all acids, alkalies, and oxidizing agents, either wet or dry. Such lubricating greases are not thickened fluids but polymers which have very poor VI.

### Special Lubricating Grease Characteristics

One of the goals of investigators attempting to produce lubricating greases from new compounds is to obtain products usable over a wide temperature range. In order to accomplish this, the lubricating fluid must have a low pour point and as flat a viscosity-temperature curve as possible. Also the lubricating fluid, the thickener, and any structure modifiers must be resistant to high temperatures. Recent disclosures indicate that thickeners are now available that have greater high temperature stability than do usable lubricating fluids.

The phthalocyanine pigments are of this class. Fitzsimmons *et al*[1] state: "The behavior of the phthalocyanine greases in laboratory and in functional tests indicates that the high temperature limit for the successful operation of grease-lubricated ball bearings is now set by the chemical and thermal stability of the oils available for grease formulation and by the metallurgy of the bearings themselves." Although 150 C (302 F) was said to be[1] the present practical limit for the use of lubricants containing copper phthalocyanine, tests in anti-friction bearings operating at 200 and 220 C (392 and 408 F) have been made. Silicon fluids were the only oils found stable at the higher temperatures and they were deficient in lubricity.

It has also been found[7] that certain substituted ureas, developed under Air Force contact, which melt above 600 F, are satisfactory thickeners for lubricating fluids. Here again the high temperature characteristics of available lubricating fluids limit the upper range of use for the resulting lubricating greases. Silicon fluids, which are not too satisfactory as lubricants, show the greatest promise in this type of product. It is stated[7] that several lubricating greases, made by thickening silicone fluids with arylureas, have repeatedly performed for over 500 hours in ball bearings operating at 450 F and 10,000 rpm.

Although thickeners of inorganic origin, which have been previously mentioned, are suggested for use in lubricating greases applicable at high temperatures, they are not entirely satisfactory. First, they have been used, almost entirely, for bodying mineral oils. Such oils, even with the most satisfactory antioxidants present, deteriorate rapidly at temperatures above 300 F. Further, the organic compounds used to render the inorganic materials water repellent, are unstable above 250 to 300 F.

At low temperatures the controlling factor seems to be the viscosity-temperature characteristic of the lubricating fluid. Thus two lubricating greases containing a diester, di(2-ethylhexyl sebacate) but thickened in one case with lithium soap and in the other case with copper phthalocyanine were compared at —65 F. Under the same conditions of test, the latter product had a much lower starting and running torque than the former. When lubricants, consisting of a silicone fluid thickened with either an arylurea or a lithium soap, were compared as to starting torque at—40 F[7] the former product showed about two-thirds the starting torque of the latter.

As a rule, lubricating greases containing non-soap thickeners exhibit shear stability comparable with the most satisfactory soap thickened products. In other words, products being considered do not soften abnormally in service.

### Application

Mention should be made of the increased use of a particular type of lubricating grease, namely *multi-purpose*. As the name indicates, such products have characteristics that permit their use for a number of applications. Such use began with use in automotive lubrication, where formerly a separate lubricating grease was employed for each of the following purposes: Chassis lubrication; steering gear lubrication; universal joint lubrication; wheel bearing lubrication; and water pump lubrication. The use of a multi-purpose lubricating grease was made possible because lubricants of high melting point and shear and structural stability were perfected. These consisted first of barium-base lubricating greases and later also of lithium-base lubricants. To this class has been added high melting point calcium base products in recent months. Also some lubricating greases made with non-soap thickeners have been suggested for this purpose.

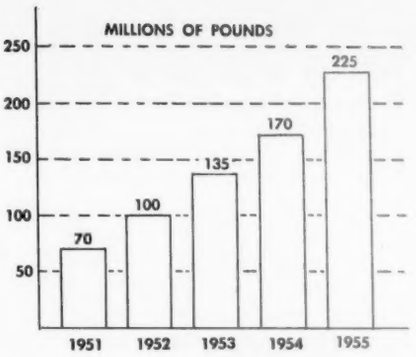


**FIG. 10. Past and projected production of lithium-base lubricating greases.**

Link[2] lists the advantages of using lubricating grease for a multiplicity of purposes as follows: Greatly reduced inventories (one lubricant can satisfy as many as 90 per cent of all requirements); the economic advantage of buying one type of lubricating grease; more simplified storage and dispensing systems; extended lubricating periods; reduced consumption; and fewer misapplications of lubricating grease.

As an indication of this trend Link[2] states that 60 per cent of the overall lubricating grease production of one manufacturer consists of a specific multi-purpose product. It is also mentioned that one company, operating perhaps 30 ore and metal processing plants, satisfies about 75 per cent of its requirements with a multi-purpose lubricating grease. Also a division of an aircraft manufacturer meets over 95 per cent of their lubricating grease requirements with a similar product.

It is of interest that the ground forces of the United States Army have been using, very successfully, one grade of lubricating grease (MIL-G-10924 Am. 2) for lubrication of automotive and artillery material under all conditions of service where ambient temperatures range from —65 to +125 F.

There is a tendency toward longer periods between servicing some equipment where lubricating greases are used. For example electric motors are often being run several years before they are inspected. Likewise anti-friction bearings on railroads are expected to continue in service for three years or longer before the lubricating grease is renewed. Such long periods between lubrication are only made possible by the improved lubricating greases now available.

An example of the change in thinking relative to the intervals for relubrication of electric motors is illustrated, as resulting from tests described by Walker and O'Meara.[8] These investi-

gators mention that the generally accepted practice for relubrication of motors of 25 hp or less at the Atlantic Refining Company's Point Breeze refinery was once every six months. This was for service of 24 hours per day. The conclusions resulting from such tests, conducted over a five year period, were that it is not good policy to operate motors of such size, bearing design, and speed in 24-hour service, without relubrication over a five-year period.

As a result of this investigation, however, the Port Arthur refinery has initiated a permanent program where motors through 25 hp capacity are scheduled for three-year lubricating intervals. This is a tribute to both the manufacturers of lubricating greases and the suppliers of bearings.

Railroads are finding lubricating greases satisfactory for use in housings of anti-friction bearings. In the case of freight cars, which are sometimes idle for extended periods, oil drains from the bearings and often permits rusting whereas some lubricating greases continue to cover and protect the bearings. Rockwell[6] sums up what is expected of lubricating greases used in anti-friction bearings of railroad rolling stock as follows: "While the present day relubrication AAR rules call for adding one pound (of lubricating grease) every 90 days for passenger equipment and one pound added to each housing once a year for freight equipment, a reasonable goal to be desired in the future is the relubrication of passenger car bearings only when the cars are shopped or when wheels are turned and at three-year air-brake inspections on freight cars."

### Future Trends

The trend in processing raw materials into finished lubricating greases is directed toward both greater throughput in a given time and more exact control of processing variables. In recent installations this has been accomplished by improvement in batch equipment and instrumentation. The reason that continuous or semi-continuous processing equipment has not been used to a greater extent is because batch equipment is more versatile.

Much of the increase in research and development of lubricating greases stems from the demands of the military during World War II. Such work has continued unabated and has led to much of the progress just described. The industry has even seen fit to finance co-operative work in the form of a NLGI Fellowship at the University of Southern California.

Although the use of thickeners of inorganic origin is widespread they have not made any great inroads on the total tonnage of thickeners for lubricating greases. At least two manufacturers of such lubricants, however, have made carload purchases of silica gel for bodying oils. Also in the case of two medium-sized plants about 80 per cent of their total production consists of "Bentone" thickened lubricants. Only one major oil company to date has marketed any substantial amount of lubricating greases of these types. Neither has the government adopted lubricants employing thickeners of inorganic origin.

Since intensive work is being carried on to improve lubricating greases containing thickeners of inorganic origin, the situation described above may not be valid in a few months. Thus one chemical company (du Pont) began intensive development work on a silica, specifically designed for use as a grease thickener, in 1949. This work has been so successful that a plant for the production of "PL-171 Fine Silica" is nearing completion and this particular silica is expected to be available in sizable amounts by the middle of 1954.

The other promising non-soap thickeners, that is the phthalocyanine pigments and substituted ureas, are not generally available at reasonable prices and hence will continue to have restricted use for the present. The fact must not be overlooked, however, that the specialty product of today may well be a commonplace one in the future.

In considering the trend in the use of lubricating greases, the following should be kept in mind. One economic fact, which is not always recognized, is that often there is no justification for paying a premium price for a specialty item when a moderate priced, conventional product will serve the end just as well. This fact may well determine what types of lubricating greases will predominate in those marketed in the future.

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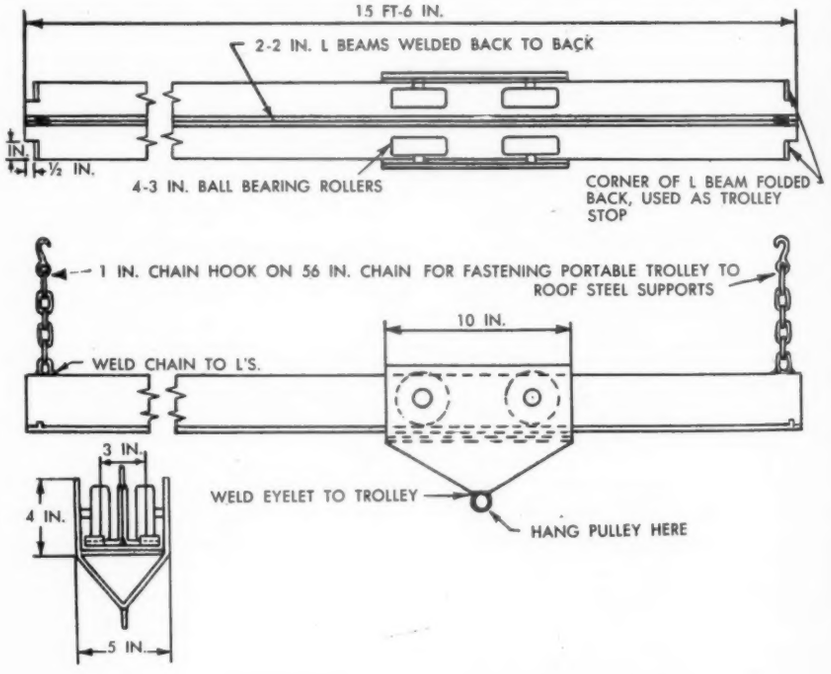
PLANT AID


15 FT-6 IN.
2-2 IN. L BEAMS WELDED BACK TO BACK
½ IN.
4-3 IN. BALL BEARING ROLLERS
CORNER OF L BEAM FOLDED BACK, USED AS TROLLEY STOP
1 IN. CHAIN HOOK ON 56 IN. CHAIN FOR FASTENING PORTABLE TROLLEY TO ROOF STEEL SUPPORTS
10 IN.
WELD CHAIN TO L'S.
3 IN.
4 IN.
WELD EYELET TO TROLLEY
HANG PULLEY HERE
5 IN.

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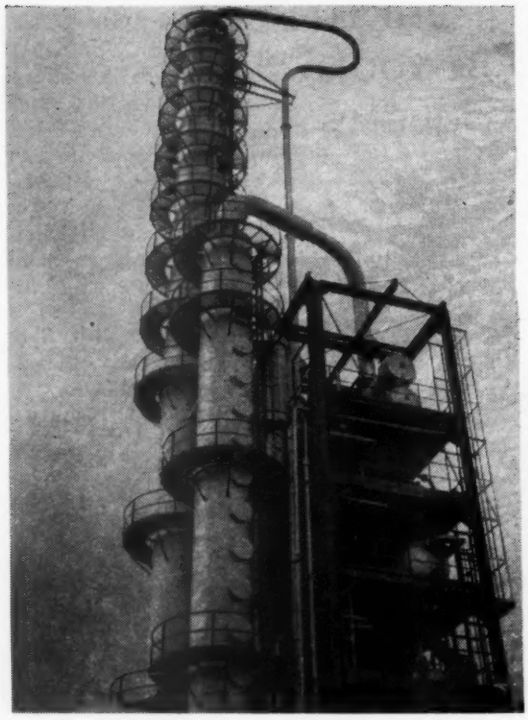
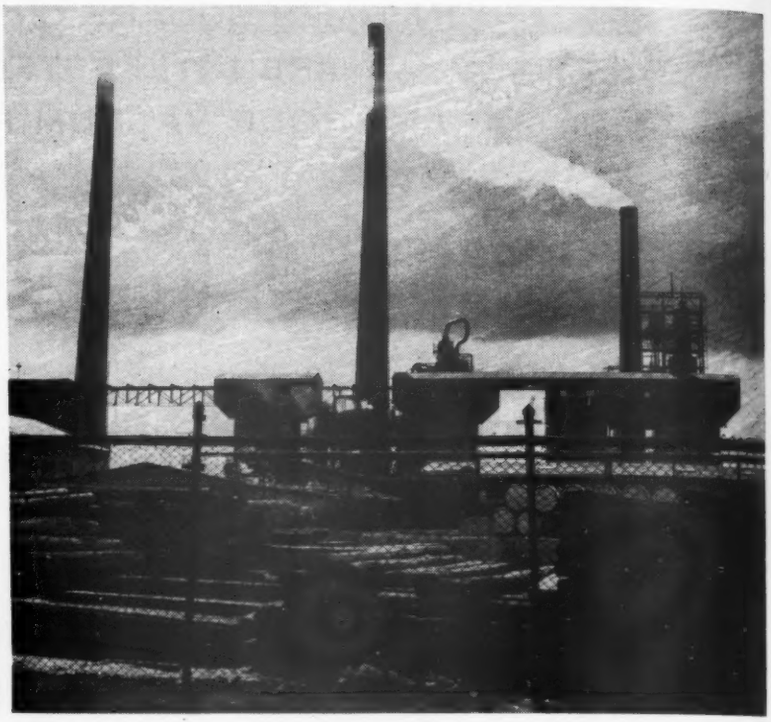


A vacuum tower and an atmospheric tower in the Hamburg, Germany, refinery of Esso-Ebano.



General backyard view of the Hamburg plant, showing European influence in covered construction.

*Photos courtesy Standard Jersey*

# Forty Per Cent Increase in Refinery Output in Germany in 1954

*German refineries installing cat crackers, reformers, poly plants; to process 19,000,000 bbl German crudes, import 50,000,000 bbl*

THE year 1953 has brought a large increase of production in the German Federal Republic's refineries and oil hydrogenation plants. At the beginning of the year about 6,500,000 tons of crude oil were planned to be processed.

Practically all of the gasoline requirements have been satisfied by more inland production and the ever increasing demand for diesel fuel will soon be satisfied from German refineries. Hand in hand with expanded production, owing to the increase in the size of the refineries, the installation of new cat cracking capacities has also enabled the industry to improve the quality and octane number of gasolines. Surplus residual fuel that cannot be absorbed at present on the market owing to special circumstances in the German industry and which mainly is used to coal as fuel, is converted in large amounts into gasolines and diesel fuels by high presure hydrogenation. These hydrogenation plants have considerably increased their throughput in the last few years and put "on stream" new cracking plants recently.

Already it is obvious that the revised AES plan shown in Table 1 has been fulfilled nearly completely.

It is anticipated that the total amount of processed crude oils will be almost 9,500,000 tons, 2,600,000 tons coming from German fields and something like 6,800,000 tons to be imported. Most of the imported oil will come from the Middle East. It is expected to obtain from Saudi-Arabia more than 3,000,000 tons, from Iraq 1,900,000 tons and from Kuwait slightly more than 800,000 tons. Approximately 850,000 tons are expected to come from Mexico and Venezuela.

The gasoline production should increase to 3,000,000 tons. In 1953, however, only 2,000,000 tons have been consumed. If there are consumed 2,300,000 tons in 1954, still 700,000 tons would remain, an amount of gasoline that would have to find its market somewhere. The anticipated production of 2,500,000 tons of diesel fuel will find its market and it appears that production and demand will be well in balance. It will also be a certain problem to use the full amount of 1,500,000 tons of residual fuel.

Table 3 gives an indication of how the major part of the increase in production is distributed among the different oil companies.

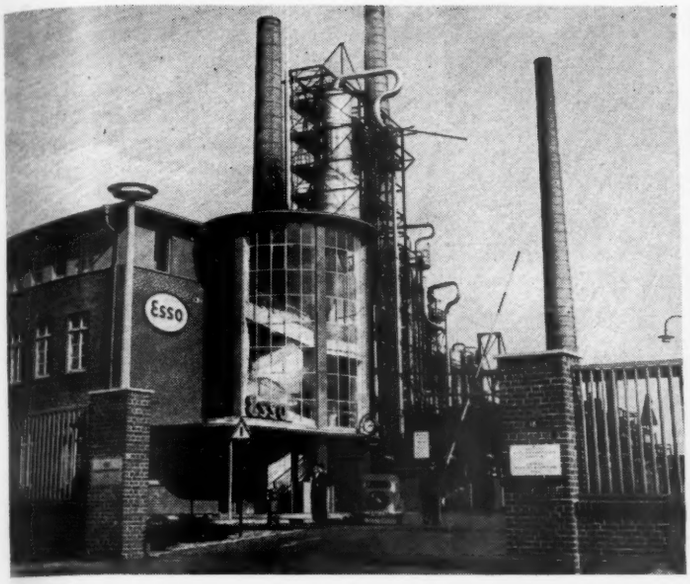
*Major Alterations in 1953*

**A. Hydrogenation Works:**

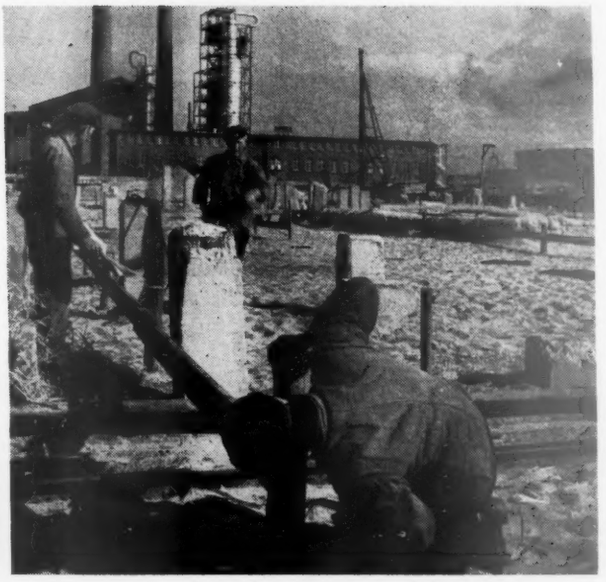
*Gelsenberg Benzin A.G. (Ruhr area)*

A TCC cat cracker with poly unit (California Research) and enlargements of the refining and hydrogenation sec-

**EXCLUSIVE**




Crude still No. 3, background, and office building, foreground, at the Esso-Ebano Harburg plant.



German workmen aligning piling for unit foundation.

*Photos courtesy Standard Jersey*

tions were brought on stream in July, 1953. The capacity of the cracker lies between 500,000 and 800,000 tons per year, topped crude. Hydrocarbon, New York, and Düsseldorf constructed and built the TCC unit (by Socony-Vacuum, New York-license), employing local firms and contractors. Lurgi-Frankfurt (by license of Lummus New York) built the polyplant and enlargements of the refinery section.[3] The hydrogen producing capacity for residual hydrogenation has been increased by adding low temperature coke oven gas separation units.

Capacity of Gelsenberg is now close to 1,800,000 tons per year. A reforming unit is planned.

*Union Rhein-Braun-Wesseling (Rheinland).*

K. Wissel[4] gives many useful figures and a comprehensive discussion of the possibilities of combined topping, thermal cracking operations, thermal reforming, and hydrogenation of the cracked residues. Yields and qualities of the products, especially gasolines are greatly improved in this combined system if compared with normal refinery practice. The question of getting rid of large amounts of residual fuel is solved by hydrogenating the residues. Thus the octane number of the hydrogasolines is fairly high, because of the aromaticity of the cracked residues. The combination process is very flexible. Cracked gases will soon be used as a basis for one of Germany's first petrochemical plants employing BASF and Shell patents. Main products will be polyethylenes and styrene, etc.

*Scholven Chemie A.G. (Ruhr area)*

In July an Orthoflow-Kellogg fluid bed, cat cracker was started up. Capacity of this plant has been increased to approximately 400,000 tons per year crude throughput. Thus it is possible now to process foreign and German crude oils together. Also Scholven is employing the combination of crude topping, cat cracking, and hydrogenating the residues. The cat cracker was built by F. Uhde K.G., Dortmund.

**TABLE 1. Revised AEV plan for 1953.**

| Refinery | Type of crude | Capacity in metric tons* |
|---|---|---|
| Gewrkschaft Erdolraffinerie... | | |
| Emsland | German | 205,000 |
| Deurag-Nerag | German | 529,000 |
| Wintershall A. G. | German | 78,400 |
| Greiser | German | 7,300 |
| BASF | German | 6,000 |
| | Aramco | 27,000 |
| BP-Olex | Irak | 730,000 |
| Deutsche Erdol A. G. | German | 337,100 |
| | Aramco | 52,600 |
| | Irak | 91,000 |
| Esso-Ebano | Tia Juana | 380,000 |
| | Aramco | 430,000 |
| Deutsche Gasolin | German | 25,800 |
| | Tia Juana | 71,400 |
| Gelsenberg Benzin A. G. | German | 417,000 |
| | Aramco | 513,000 |
| Kraftstoff H. G. | Aramco | 33,800 |
| Mawag | Mexico | 60,000 |
| Pfeifer | Aramco | 7,800 |
| Ruhrbau | Aramco | 200,000 |
| Ruhrchemie | Kuwait | 62,500 |
| Ruhrol | Aramco | 54,000 |
| Shell-Monheim | German | 6,500 |
| | Lagunillas | 193,000 |
| Shell-Harburg | Irak | 446,000 |
| | Heavy S. fuel | 75,000 |
| Schindler | Irak | 198.000 |
| Scholven | German | 178,200 |
| | Kuwait | 130,000 |
| Deutsche Vacuum Öl A. G. | German | 112,400 |
| | Aramco | 591,000 |
| Wesseling | German | 165,000 |
| | Kuwait | 500,100 |
| Zeller und Gmelin | Aramco | 4,000 |
| | total: tons | 6,939,100 |
| | total: bbl | 51,765,700 |

*Note. One metric ton contains approximately 7.46 bbl (42 gal), of 36 API gravity crude oil. This factor may be used to approximate the number of barrels in the tons figures shown in this article—Editor.

**TABLE 2. An indication of the A.E.V. plan for 1954.[2]**

| Refinery | Type of crude | Capacity in metric tons* |
|---|---|---|
| Gew. Erdolraff. Emsld | German | 500,000 |
| Deurag-Nerag | German | 542,000 |
| Wintershall | German | 90,000 |
| Greiser | German | 8,000 |
| | Aramco | 12,000 |
| BASF | German | 16,000 |
| | Aramco | 27,000 |
| BP | Irak | 1,213,000 |
| Deutsche Erdol A. G. | German | 400,000 |
| | Aramco | 82,000 |
| | Irak | 50,000 |
| Esso-Ebano | Tia Juana | 360,000 |
| | Aramco | 1,415,000 |
| Deutsche Gasolin A. G. | German | 24,000 |
| | Tia Juana | 78,000 |
| Gelsenberg Benzin A. G. | German | 487,000 |
| | Aramco | 713,000 |
| Kraftstoff H. G. | Aramco | 60,000 |
| Mawag | Venezuela/Mexico | 100,000 |
| Pfeifer | Aramco | 15,600 |
| Ruhrbau | Aramco | 230,000 |
| Ruhrchemie | Kuwait | 175,000 |
| Ruhrol | Aramco | 120,000 |
| Shell-Monheim | Lagunillas | 200,000 |
| Shell-Harburg | Irak | 460,000 |
| | Tia Juana | 120,000 |
| Schindler | Irak | 200,000 |
| Scholven | German | 160,000 |
| | Kuwait | 240,000 |
| Deutsche Vacuum | German | 120,000 |
| | Aramco | 580,000 |
| Wesseling | German | 280,000 |
| | Kuwait | 416,000 |
| | total: tons | 9,494,400 |
| | total: bbl | 70,828,200 |

## B. Refineries.

*B. P.-Hamburg*

Work has been progressing well in the BP refinery. They are establishing

**TABLE 3.**

| Company | Crude oil processed in 1953, metric tons | 1954 anticipated, metric tons |
|---|---|---|
| Esso-Ebano Hamburg | 810,000 | 1,775,000 |
| BP Hamburg Finkenwerder | 730,000 | 1,200,000 |
| Gelsenberg-Benzin A. G. | 930,000 | 1,200,000 |
| Emsland Raff. Lingen | 205,000 | 500,000 |
| Scholven | 308,000 | 400,000 |
| Ruhrchemie | 62,000 | 175,000 |



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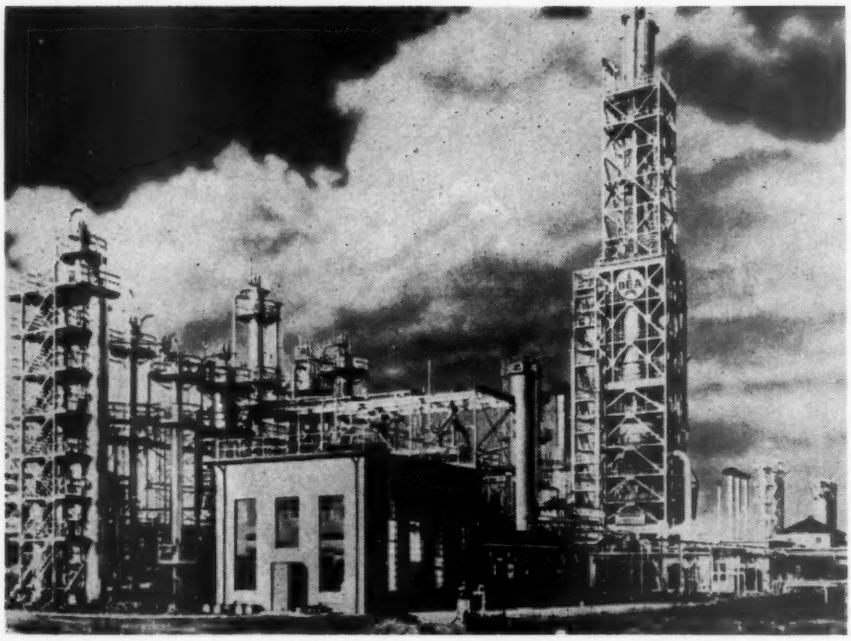


**A Thermofor Catalytic Cracking unit in the refinery of Deutsche Erdol Aktien Gesellschaft, in Holstein, Germany.** *—Courtesy, Socony-Vacuum.*

Germany's first Platformer with a reforming capacity of more than 300,000 tons per year and larger distillation capacities by adding atmospheric and vacuum towers for nearly 600,000 tons per year. After completion BP expects to have a capacity of approximately 1,250,000 tons per year.

*Deutsche Erdöl A. G. Holstein*

Their TCC cat cracker licensed by Socony-New York, was built for processing 300,000 tons per year, mainly German crude oils. With the light Holstein crude available, however, it may be possible to increase the throughput above this given figure.[5]

*Deurag-Nerag, Misburg refinery:*

By adding a poly plant (Hydrocarbon-Düsseldorf) throughput 75 tons per day liquid gas and a thermal reformer (Lurgi-Lummus) with a capacity of 9000 tons per month of heavy naphtha, the quality of gasolines from German crude has been raised considerably.

*Esso-Ebano, Hamburg:*

The Ebano refinery at Hamburg-Harburg has been working on a plant expansion program comprising a cat cracker, vacuum-distillation, and cat reformer, having a capacity of altogether 1,000,000 tons per year. Addition of these units will increase the total capacity of this refinery to 1,700,000 tons per year.[6]

*Gewerkschaft Erdölraffinerie Emsland, Lingen:*

The newly erected Houdriflow cat cracker was started up last summer. Unfortunately in August fire damaged the cracking tower. The unit was repaired, however, and brought on stream in January, 1954. Lingen is processing crude oils from the Emsland fields which are expanding.

*Deutsche Vaccum Ol A. G. Bremen*

With the capacity of 450,000 tons per year throughput their TCC cat cracker (licensed by Socony New York) is processing mainly crude from Middle East fields. The construction and erection of the unit was done mainly by local firms. The refinery produces gasolines, diesel fuels, etc., as well as lubricants. H. Hartmann gives a comprehensive description of the activities of this refinery especially of the cat cracking section.

*Fischer Tropsch works: (Synthesis):*

Because of high coal prices in Germany at the moment F.T. plants in the Federal Republic do not produce gasolines from coal as a main product now. Instead they have cancelled production altogether or changed to the manufacture of other products, important for the manufacture of petrochemicals. For instance Krupp-Kohlechemie Wanne Eickel (Ruhr) are now concentrating their efforts to produce hard paraffin waxes of improved qualities, among other products.

*Rheinpreussen A.G. (Ruhr)*

In laying emphasis on research, improved F. T. techniques and catalysts have been developed. In a large pilot plant in the Ruhr area the new synthesis process, CO + steam, will be tested and further investigations on larger scale will be done.

Chemicals like isopropyl alcohol and secondary isobutyl alcohol are manfactured. Laquers and synthetic resins, pharmaceuticals, etc,, are in the planning stage. Instead of synthetic lubricants based on naphthalene, alkylbenzene is now produced as a basic material for detergents.

Some of the F.T. works like Ruhrchemie are now processing crude oils and have been planning to build cracking units eventually.

### References


1. Erdöl u. Kohle 6, 427 (1953).
2. Erdöl u. Kohle 6, 752 (1953).
3. Erdöl u. Kohle 6, 508 (1953).
4. Erdöl u. Kohle 6, 696 (1953).
5. Erdöl u. Kohle 6, 17 (1953).
6. Erdöl u. Kohle 6, 233 (1953).
7. Erdöl u. Kohle 6, 103, 385 (1953).


* * *

PLANT AID

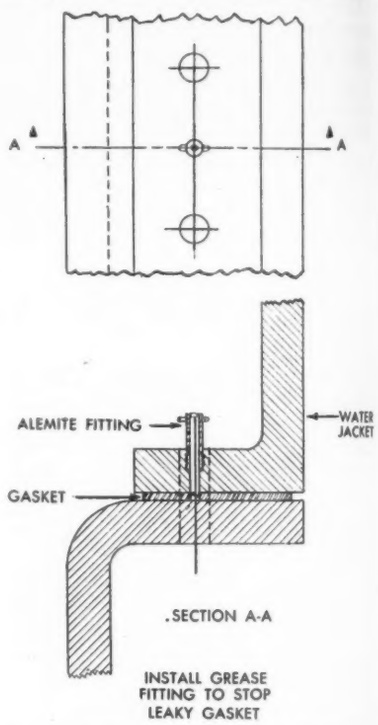
## Stopping Gasket Leaks*


GEORGE NEEDHAM†


*Purpose:* To stop gasket leak without replacing gasket.

*Description:* When a gasket leak occurs where a shutdown or considerable time would be required to facilitate repairs, this method can be used.

Drill a hole through one flange and into the gasket. Tap the hole to take an

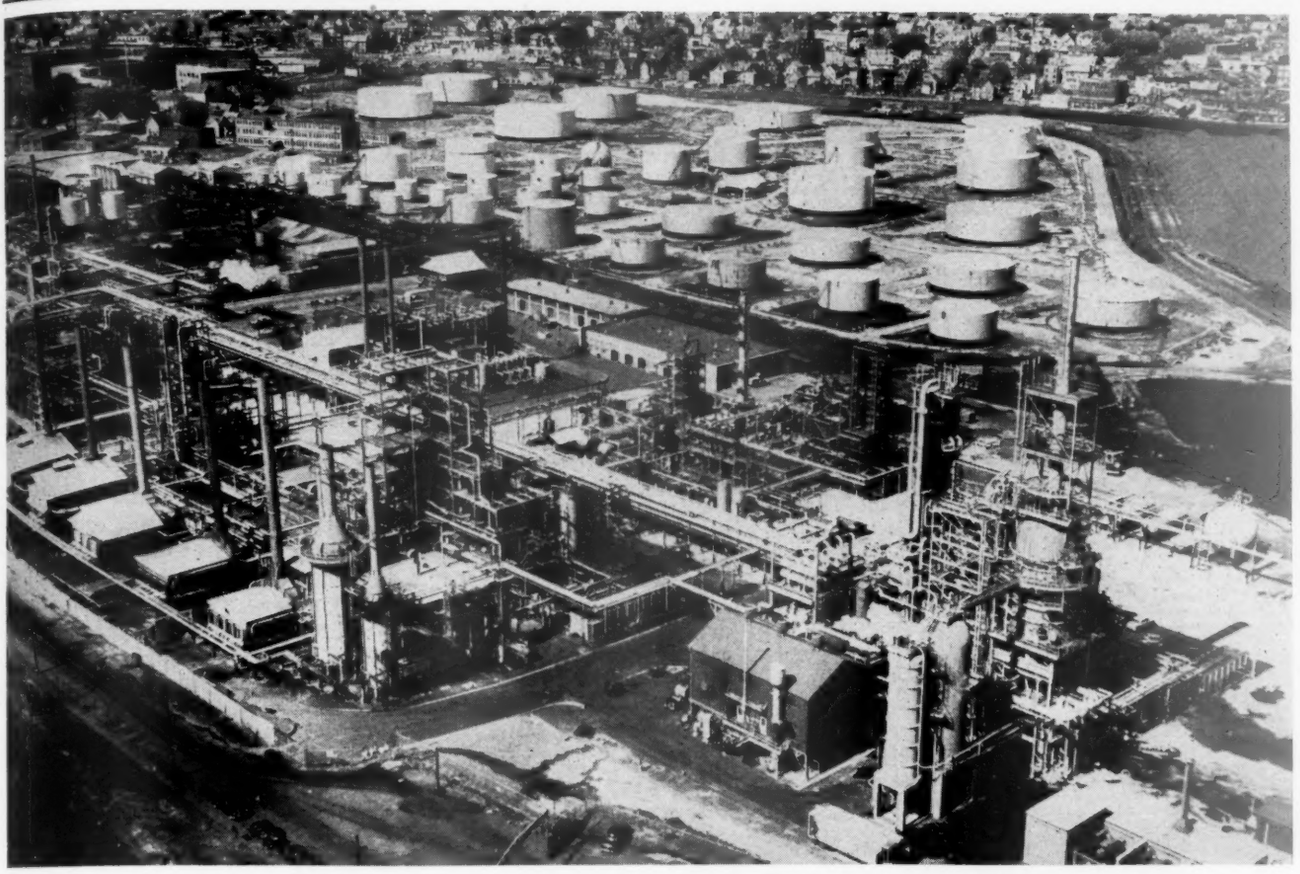



alemite fitting. Then load a grease gun with permatex No. 1 and shoot into the gasket. The permatex will seal the leak.

We used this method to repair a gasket leak between the water jacket and crankcase on a Bruce-McBeth engine. A large stream of water was running through the gasket. To replace the gasket in this case a five-day shutdown and a labor bill of about $600 would have been required. By using this method and making two taps the leak was stopped in about 20 min and the engine was not shutdown. This was done several months ago and to date no further leaking has occurred.

*Class A, second prize at NGAA—Permian Basin regional meeting.

†Engine repairman, Phillips' Hobbs plant.



Everett, Massachusetts refinery of Esso Standard with new 24,000 bbl fluid catalytic cracking unit (right foreground).

# REVOLUTION in Refining

*Catalysts make possible the conversion of molecular structure at will of refiner*

Catalytic cracking has, literally, revolutionized petroleum refining, and has made possible greatly accelerated development of the petrochemical industry, all in the space of 15 years. During this time we have fought the greatest war in history, have won it, and have assumed the foremost role in international world political activities, have developed over-night the lustiest industrial infant the world has ever seen—the petrochemical industry.

**EXCLUSIVE**

The petroleum industry has wrested from other industries the controlling seat in aromatics production, formerly entirely a coal tar industry and product. More alcohols, glycols, glycerine, and plastics are now or soon can be made from petroleum and natural gas hydrocarbons than have ever been made from all other raw materials sources.

And the major portion of all this accomplishment is traceable to one agency, the "lowly" catalyst, that Alladin's Lamp, that powers reactions not possible otherwise, and then disappears from the scene, a regular "Lone Ranger" of the chemical industry.

In the following pages are presented essential principles of catalytic cracking, and the detailed stories of how each of the currently employed processes is carried out, its yields and products. It is a far cry from the processing methods of 1942 and those of this year, 12 years later. Advances in the industry, spurred on by war's demands, during this period represented the "normal" accomplishments of half a century, and the peak of expansion is not yet in sight. In fact, expansion is so rapid that published figures are partially out of date.

The facts given in these four articles constitute a condensed encyclopedia of up-to-the-minute data on the latest in catalytic cracking. Within this restricted space will be found the most complete data on the controlling principles and methods ever published in such brief form on these processes.—Editor.

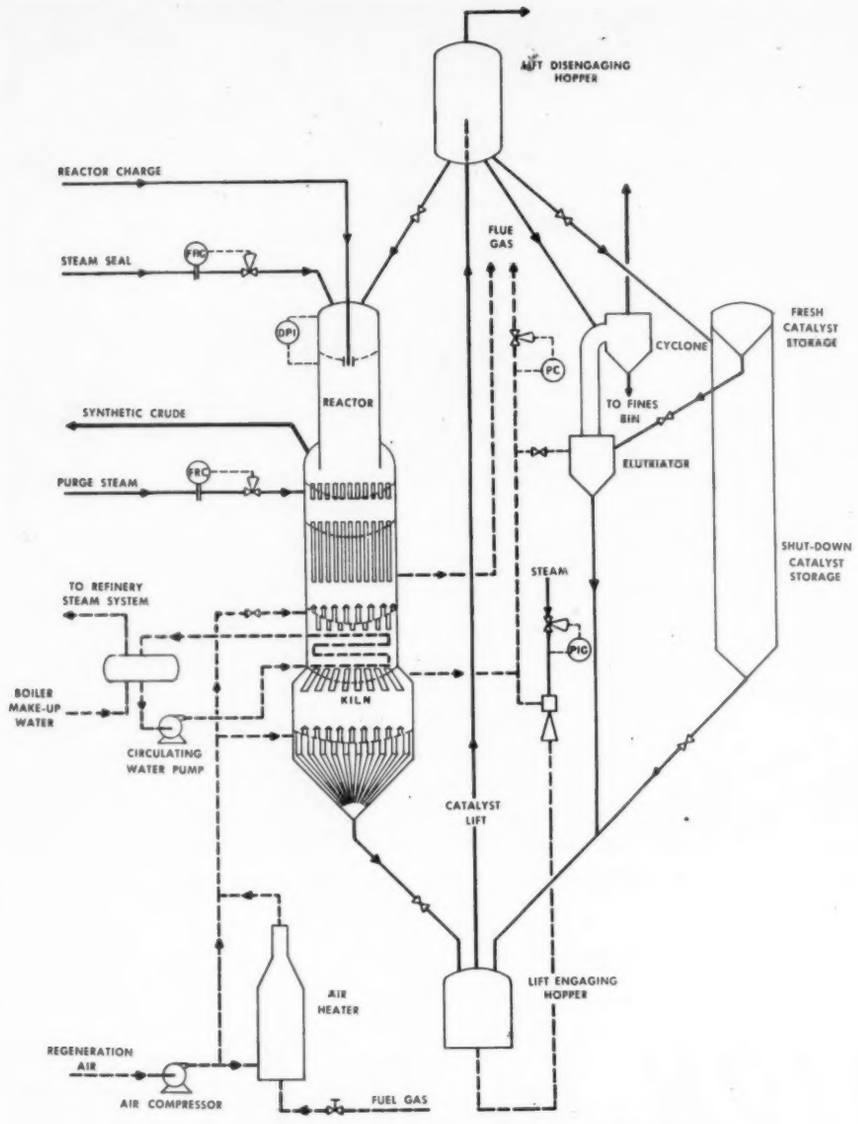



**FIG. 1. Flow diagram of Houdriflow catalytic cracking process.**

# Houdriflow

*Ease of operation, low maintenance-operating cost, high catalyst activity, charge flexibility typical of this routine*

**A. WESLEY HOGE***

AT present there are fourteen commercial Houdriflow units in operation and five others under construction, which in the aggregate have a nominal design charge capacity of 224,550 bbl per day. Experience over the past several years on the fourteen operating Houdriflow installations has established a highly satisfactory record. Highlighting this record are the following: Ease of operation under normal operating conditions and in emergencies, low maintenance and operating cost, ability to use all types of commercially available cracking catalysts, maintenance of high catalyst activity with low catalyst make-up cost, flexibility as to type of charge stocks handled and conversion levels attained.

Motor gasolines produced by Houdriflow catalytic cracking operations have F-1 octane values in the range of 88-94 F-1 clear and 95-99 F-1 + 3cc TEL depending upon the temperature level, the type of charging stock, and catalyst. In addition to gasoline, the $C_3$ and $C_4$ light products are rich in unsaturates which may be further processed for the production of alkylate, polymer gasoline, or used in the petrochemical industry. A large percentage of the catalytic gas oil is light in boiling range and suitable for blending to No. 2 fuel. This light catalytic gas oil can also be blended into diesel fuels. Due to its relatively low viscosity, the small quantity of heavy catalytic gas oil produced is readily utilized as residual fuel cutter stock.

Commercial Houdriflow units have operated with all of the commercial cracking catalysts — synthetic silica-alumina bead, natural clay, and sulfur resistant clay catalysts. Similarly, a wide variety of petroleum distillate stocks are being catalytically cracked in Houdriflow operations. Sweet and sour stocks, representing fractions of crudes boiling between naphtha and penetration asphalt, are handled equally well. The reactor charge, (which is introduced through a common oil feed nozzle) may be all vapor, all liquid, or mixed vapor and liquid. Commercial units have operated with 80 to 90 per cent of the feed in liquid phase. In some units conversion above 90 per cent is being achieved using recycling to tresh feed ratios of 1/1 or slightly more, while elsewhere once-through cracking is preferred at 50-60 per cent conversion. In some instances accumulated cycle stock has been the total reactor feed.

The ease with which Houdriflow units are put on stream or, in the event of an emergency, taken off stream, is one of the outstanding characteristics of the design. Upsets in refining operations resulting from power outages, mechanical failure of gas compressors, and similar occurences outside of catalytic unit are taken in stride by Houdriflow units with a minimum of lost time after the difficulty is corrected. Onstream efficiency of Houdriflow units averages better than 90 per cent.

High onstream efficiency has been achieved with low maintenance cost. Periodic inspections have repeatedly shown that the wear and tear on Houdriflow units is very nominal, necessitating only minor repairs.

### Originial Process Modified

The continued acceptance of Houdriflow has been accompanied by a number of significant improvements and simplifications of the process. In the original Houdriflow design, the reactor and kiln were superimposed with

*Houdry Process Corporation.

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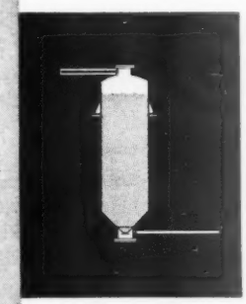

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a short seal leg between the vessels. This arrangement has been modified in the current design in which the kiln and reactor are integrated in a single vessel. The single shell permits a decrease in the height of the unit and also eliminates the problem of collecting the catalyst from the reactor and redistributing it in the kiln.

An improved lift arrangement now permits the kiln to operate at low pressures (less than 5 psig) with only a single stage blower required for regeneration air. All problems of pressure balance between the kiln and reactor are eliminated. Steam jet compressors are employed to compress flue gas from the kiln and deliver motive gas to the lift system at a constant rate. A feature of this design is that the reactor may be by-passed at any time without disturbing the pressure balance of the kiln and lift systems.

The new catalyst drawoff system employed in Houdriflow operations assures uniform catalyst flow through the reactor and kiln for obtaining the maximum efficiency. An improved cooling coil design eliminates outside header boxes and reduces cost, while simplifications in equipment have further reduced the already low cost of alloy protection required for processing high sulfur stocks.

### Description of Houdriflow Process

Fig. 1 is a simplified process flow diagram of a typical Houdriflow design. Details of the integral reactor-kiln vessel are shown in the cut-away diagram in Fig. 2.

The unit is arranged in a compact manner and requires a ground area of approximately forty by sixty feet. The major components of combination reactor-kiln vessel, catalyst storage vessel, catalyst lift, catalyst elutriator, catalyst fines separator, single stage air blower and air heater. The two major vessels (combination reactor-kiln and hot catalyst storage) are self supporting, and may be located on opposite sides of a steel structure which houses a stairway and supports the catalyst lift and the catalyst elutriator. Other arrangements are possible to fulfill special space and location requirements.

To trace the oil circut briefly, charging stocks, either vapor or liquid or mixtures of the two, flow through a specially designed nozzle into the reactor. The cracked vapors are separated from the catalyst in a disengager and flow to the synthetic crude tower. The catalyst is next purged with a countercurrent flow of low pressure steam in a short purge section to remove residual oil remaining on the catalyst. The hydrocarbons stripped from the catalyst in the purge section join the main stream of cracked vapors and flow to the fractionating column.

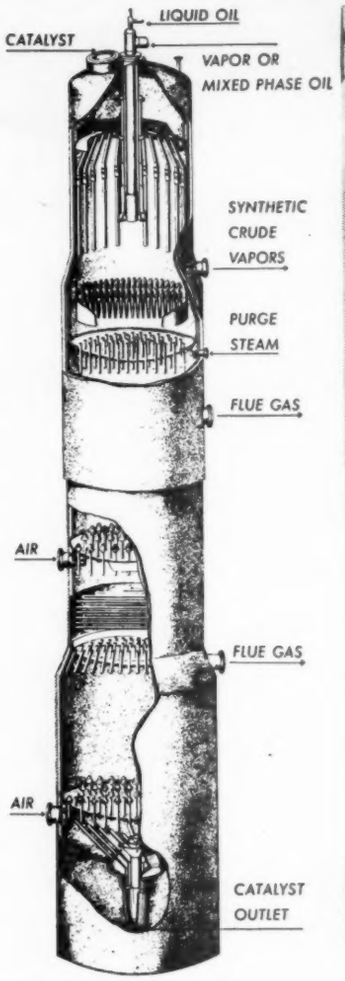


**FIG. 2. Details of Houdriflow integral reactor-kiln vessel.**

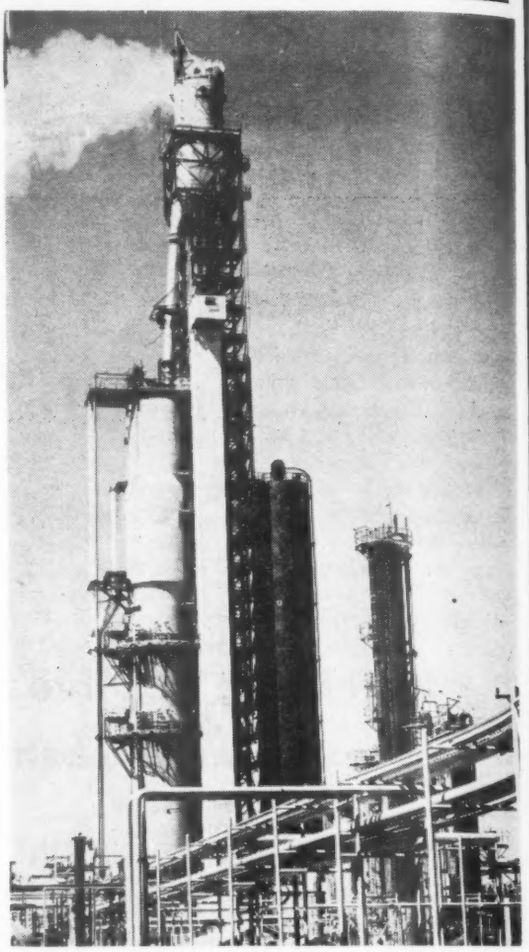

**FIG. 3. A recent houdriflow cat-cracking unit started at Texas City Refining Company's plant.**

Tracing the catalyst flow, regenerated catalyst from the gas lift flows by gravity from the lift disengager through the top seal leg, reactor, purge section, intermediate seal section, kiln and transfer line to bottom of lift. Approximately 75 per cent of the catalyst entering the reactor flows down through a center pipe in this head and is admitted to the cracking zone through an annular orifice which surrounds the hydrocarbon feed nozzle. The remainder of the catalyst stream enters the cracking zone through a circle of pipes located near the periphery of the vessel. These pipes serve to maintain the top of the catalyst bed at the desired level, which in effect sets the space velocity.

Following the reactor the catalyst flows through the purge section, intermediate seal section, and enters the kiln where the coke deposit is removed by combustion with counter-current flows of air. Excess heat of regeneration is extracted from the catalyst by means of transverse cooling coils and is recovered in the form of steam.

After passing through the kiln the catalyst flows through an improved collecting device into a single line through which it flows to the lift engager. A mixture of flue gas and steam from the thermocompressor lifts the catalyst to the top of the unit, thereby completing the catalyst cycle.

Air is supplied to the kiln from a single stage centrifugal blower which discharges at about 5 psig pressure. The air stream divides and enters the kiln at the bottom of each of the two burning zones. An air heater is provided for start-up and as a means of control during operation if desirable.

Some of the flue gas from the lower zone is compressed in the jets with 100 psig steam to a pressure of about 6 psig to serve as the catalyst lifting medium. Another part of the lower zone gas is used for elutriation and the remainder, together with flue gas from the top zone, is discharged directly to the stack.

**TABLE 1. Commercial houdriflow unit material balance 90.7 per cent conversion.**

| | Volume per cent | Lb/hr | Weight per cent |
|---|---|---|---|
| Charge: | | | |
| Fresh gas oil | 100 | 59,166 | 100 |
| Recycle gas oil | 121 | 74,195 | — |
| Products: | | | |
| Gasoline, $C_5$+430° EP. | 65.1 | 33,942 | 57.4 |
| Light catalytic gas oil | 7.1 | 4,324 | 7.3 |
| Heavy catalytic gas oil | 2.2 | 1,372 | 2.3 |
| Butanes | 10.3 | 4,041 | 6.8 |
| Butylenes | 9.7 | 4,056 | 6.9 |
| Propanes | 4.6 | 1,616 | 2.7 |
| Propylene | 8.4 | 2,930 | 5.0 |
| Total $C_3$+liquid | 107.4 | 52,281 | 88.4 |
| Ethane | | 821 | 1.4 |
| Ethylene | | 441 | 0.7 |
| Methane | | 958 | 1.6 |
| Hydrogen | | 65 | 0.1 |
| Total dry gas | | 2,285 | 3.8 |
| Coke | | 4,600 | 7.8 |
| Total | | 59,166 | 100.0 |
| Conversion | 90.7 | | |

Excess heat resulting from regeneration of the catalyst is removed by water, circulated through the kiln cooling coils at a high rate relative to vaporization, and is subsequently flashed to produce steam in a high-pressure steam drum. Normally, steam production by this means is used for operation of the air blower, pumps and thermocompressors. Steam requirements for catalyst purging, sealing, etc., are supplied by low pressure exhaust steam from pumps.

In order to remove small catalyst particles from the system, about 5 per cent of the circulating catalyst is withdrawn continuously from the bottom of the lift disengaging hopper — passed through the elutriator where a countercurrent stream of flue gas strips the catalyst of fines.

Catalyst storage is a partitioned, self-supporting vessel, with adequate capacity to hold the entire catalyst inventory of the Houdriflow system as well as a nominal quantity of fresh catalyst.

The major process variables are temperature, catalyst/oil ratio, and space velocity. Regulation of these variables, along with the extent of internal recycling, makes the cracking process extremely flexible with respect to product distribution and quality required. Normal operating conditions fall in the range of 850-925 F temperature, 5-10 psig pressure 1.5-4 space velocity and 3-7 catalyst/oil ratio.

### Shamrock's Houdriflow Operations

The results currently achieved with the Houdriflow process are illustrated by the experience of the Shamrock Oil and Gas Corporation at its McKeee refinery in Sunray, Texas. In 1951 Shamrock replaced its Dubbs and cycloversion units with a Houdriflow unit designed to process 11,000 BSD of charge stock consisting of 5900 BSD of mixed atmospheric and vacuum gas oils and 5000 BSD of internal recycle. The Shamrock Houdriflow handles a wide-cut gas oil including a vacuum distillate with a boiling range in excess of 1100 F.

In addition to increasing the yield of gasoline 30 per cent over that previously produced by the thermal process, Houdriflow operations also have afforded a significant reduction in the total production of heavy fuel from 18 to 12.5 per cent on crude. The composite refinery gasoline blend currently averages 90 F-1 octane. Although designed for normal conversion of 70 vol per cent of the virgin gas oil feed, the Shamrock unit has consistenly operated at 85 per cent conversion levels, and at times above 90 per cent. The unit material balances for typical operations at 90 per cent conversion are shown in Table 1.

After polymerization of the $C_3$ and $C_4$ unsaturates and pressurizing the combined cracked and polymerized gasoline, the total yield of 10 lb RVP gasoline from the Houdriflow unit is 78-80 vol. per cent of the fresh reactor charge. This type of operation is attractive to the refiner whose limited fuel oil market puts premium on obtaining maximum yields of gasoline.

During 1953 Shamrock installed a propane deasphalting unit to further reduce the fuel oil problem. The gas oil from the deasphalting unit constitutes approximately the 90-96 per cent cut, leaving only 4 per cent asphalt bottoms, based on crude. The extremely heavy gas oil from deasphalting has been blended into the normal Houdriflow charge, and cracked to a good product distribution.

**TABLE 2. Houdriflow units in operation.**

| No. of units | Nominal capacity bsd | Company | Location |
|---|---|---|---|
| 1 | 6,750 | Tide Water Associated Oil Co. | Drumright, Okla. |
| 4 | 30,000 | Sun Oil Company | Toledo, Ohio |
| 1 | 5,000 | Petco Corporation | Blue Island, Ill. |
| 1 | 13,000 | Salt Lake Refining Co. | Salt Lake City, Utah |
| 2 | 25,000 | California Refining Co. | Barber, N. J. |
| 1 | 11,000 | Shamrock Oil & Gas Corporation | Sunray, Texas |
| 1 | 11,500 | Standard Oil Co. of Tex. | El Paso, Texas |
| 1 | 19,000 | Texas City Refining Co. | Texas City, Tex. |
| 1 | 18,500 | Gewerkschaft Emsland | Lingen, Germany |
| 1 | 11,000 | Sun Oil Company | Sarnia, Ontario |

NOTE: Additional Houdriflow units are being engineered and constructed having an aggregate charging capacity of 73,800 BSD.

### Commercial Installations

In Table 2 are tabulated the 14 Houdriflow units currently in operation, having a total nominal charge capacity of 150,750 bbl per day. In addition to these, five more units are being engineered and constructed, with a total capacity of 73,800 bbl per day. Thus the total Houdriflow capacity in operation and under construction now stands at 224,550 bbl per day. * * *

# Orthoflow†

## *Adaptation of the fluid catalyst principle to catalytic cracking has produced a greatly simplified, lower cost unit*

**H. P. WICKHAM***

THE petroleum refining industry is well aware of the importance of the Fluid catalytic cracking process. The large number of plants that have been installed and are now operating bear witness to the fact that these units are almost ideally suited to a refinery's requirements for converting heavier petroleum fractions to the gasoline boiling range, providing high yields of high octane product, as well as lighter hydrocarbon fractions required as feed stocks for auxiliary refining steps or for the manufacture of petrochemicals. Of particular significance in every day usage is the ability of the fluid process to handle feed stocks of any boiling range, at the same time having the inherent flexibility to permit the variation of operating conditions and conversion, which is essential to meet constantly changing market demands.

From the large number of installations and more than ten years of operation a tremendous amount of experience has been accumulated along engineering lines and also from the standpoints of developing process techniques and operating know-how, which have facilitated constant accomplishment in the direction of improving plant designs. Progress along these lines at any particular time is best described in terms of the units currently being built and operated. →

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Flint Steel Corporation
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The Foxboro Company
France Packing Company
Franklin Supply Company
Fuller-Austin Company
The Garlock Packing Company
Gasoline Plant Constr. Corp.
General Electric Co.
J. B. Gill Company
The Girdler Company
Goulds Pumps, Inc.
Graver Tank & Mfg. Co., Inc.
Grebe & Doremus Process Co.
Greene Brothers, Inc.
The Griscom-Russell Co.
Grove Regulator Co.
D. W. Haering and Co., Inc.
The Happy Company
Hercules-Lupfer Engine Sales Company
The Hilliard Corporation
Hudson Engineering Corp.
The Industrial Insulators, Inc.
Industrial Scientific, Inc.
Infilco, Inc.
Ingersoll-Rand Company
Johns-Manville Sales Corp.
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The Orthoflow catalytic cracking plant, although relatively new in the fluid cracking picture is the result of this urge for improvement. The name itself was employed to designate the particular features of the design in which one reaction zone is positioned directly above the other with straight lines for transfer of catalyst from one zone to another. Its simplified design provides not only a pleasing appearance, but represents savings in terms of materials, engineering, and construction costs. In addition, the Orthoflow plant represents improvements over earlier designs by way of increased accessibility for operation, inspection, and maintenance.

The Orthoflow principle of straight line vertical flow has been embodied in two different physical arrangements, both of which are now in successful operation. In Fig. 1 is presented the diagrammatic arrangement of reaction and regeneration system generally referred to as the Orthoflow A arrangement. In this system the reactor is positioned directly above the regenerator, the two being combined into a single vessel on a common supporting foundation. Regenerated catalyst flows from the regenerator bed through the port of a plug valve, the stem of which is hollow to permit the injection of oil being fed to the reactor. The oil is vaporized by the hot catalyst and serves as carrying vapor to transport the catalyst upward through the riser and into the reaction zone. A grid is provided in the lower part of the reaction zone to effect uniform distribution over the cross-sectional area. In the reactor proper the catalyst disengages from the rising vapors forming a bed above the grid and after this settling has occurred the product vapors pass through cyclone separators for additional removal of catalyst before the vapors are passed to the fractionation and recovery equipment. Catalyst flows from the reactor bed through openings in a vertical partition wall into the spent catalyst stripping zone where it is contacted with rising steam to displace residual hydrocarbon and to strip out absorbed material.

Product vapors from the stripping operation join the reactant vapors for subsequent handling and spent catalyst from the base of the stripper enters the top of the standpipe, thence flowing downward and being returned to the regeneration zone. A plug valve is provided at the base of this standpipe to control the rate of flow of catalyst so as to hold the desired catalyst level in the reactor. This spent catalyst plug valve is positioned automatically by the differential pressure instrument used as reactor level controller. The positioning of the regenerated catalyst plug valve is likewise automatic, being actuated by the reactor temperature controller.

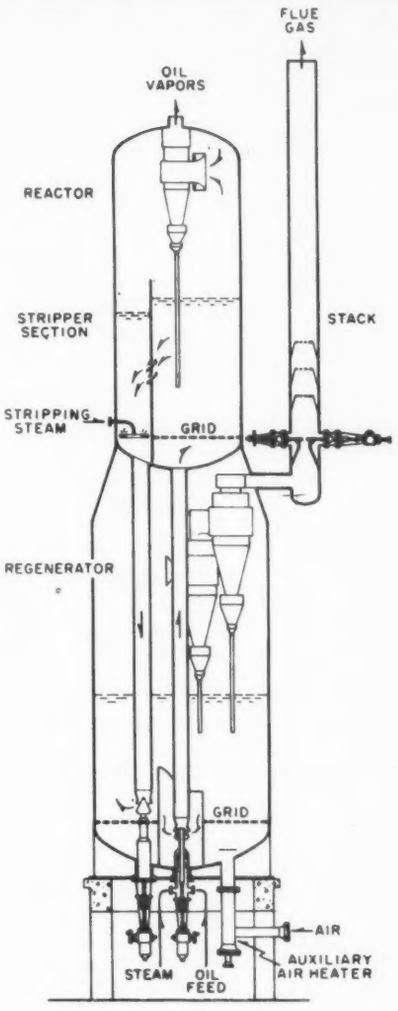


**FIG. 1. Orthoflow A catalytic cracking vessel.**

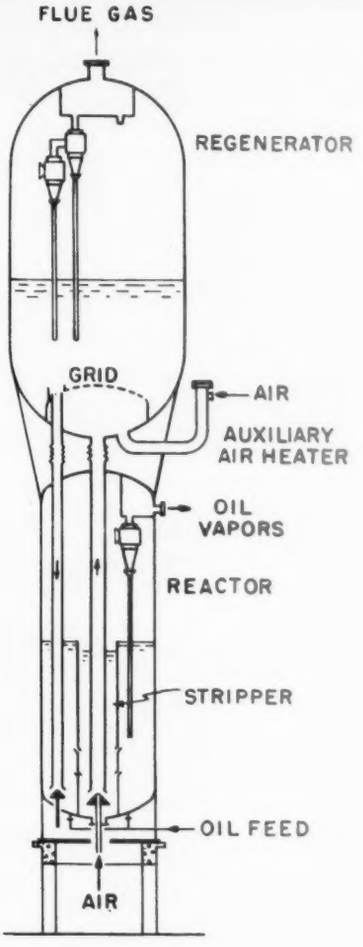


**FIG. 2. Orthoflow B catalytic cracking vessel.**

An alternate arrangement shown diagrammatically in Fig. 2 is generally designated as the Orthoflow B. In this system the regenerator is positioned directly above the reactor-stripper with a conical adapter section between the shells of the two vessels. The entire load is again carried on a single support system at the base of the reactor. As in the Type A Orthoflow, catalyst is circulated from one zone to the other through straight vertical lines at the base of which are located plug valves for regulation of catalyst flow rate.

In the Orthoflow B arrangement shown the spent catalyst stripping zone is positioned centrally within the reactor vessel and stripped spent catalyst is conveyed upward with a portion of the regeneration air which is admitted through the hollow stem of the spent catalyst valve. Regenerated catalyst flows vertically downward through the standpipe and is contacted in the base of the reaction zone with oil feed which is admitted through a number of injection points to provide adequate distribution.

At the time of writing this article there are six Orthoflow units in routine operation and six more are in various stages of completion, several of which are nearly ready for operation. The last two to be placed in service were of the B type and several of the Orthoflow A units have been in use for more than two years. Certain characteristic features stand out in the performance record of these units. They are extremely responsive to operating control, the straight line ducts providing adequate controllable circulation of catalyst for the desired conditions of temperature or space velocity. In routine operation the pressure differentials across the control valves are remarkably steady, and although pressure surges or other operating upsets must be reckoned with in any realistic consideration of operation, the ease

and speed with which these units can be returned to normal after such an upset are truly remarkable. Operating experience has also demonstrated that these units can be shut down for inspection and returned to normal operation in much shorter times than were required for earlier designs.

Of particular importance to the refiner using a catalytic cracking operation is the ability of a process unit to stay on stream with unscheduled shutdowns as few as possible and scheduled turnarounds as short as possible. The Orthoflow cracking unit is outstandingly dependable and because of its straight line flow systems is remarkably free from erosion. As would be anticipated erosion tendencies tend to concentrate in wear of the plugs of the valves controlling catalyst circulation, this being the one location where the direction of catalyst flow is markedly changed.

These plugs are of rugged design so that they will be able to withstand erosive action of the catalyst, and they have been found in use to have greater lasting power than the slide valves used in earlier designs. Also, since the wear is uniform about the periphery of the plug, the ability to control catalyst flow rate is not impaired. In the operating experience to date no emergency shutdown has been occasioned by erosion of the Orthoflow circulation system.

Also of considerable importance to the refiner is the operating cost which he must pay for the catalyst lost from the system. The Orthoflow units currently being operated on synthetic catalyst consistently show stack losses amounting to not more than 0.15 lb of catalyst per barrel of throughput. These plants are being operated on a variety of feed-stocks and at conversion levels throughout the range of 50 per cent to 80 per cent, depending on seasonal conditions and refinery requirements.

The choice of whether Orthoflow A or Orthoflow B is best suited to a particular refinery application is dependent largely on the economic considerations which apply locally. It will be appreciated that the pressure balance of the Orthoflow A must be such as to permit continuous catalyst circulation, on which account the regenerator must operate at a pressure about eight pounds per square inch higher than reactor pressure. In the case of the Orthoflow B, the regenerator operates at a pressure below the reactor pressure and while the physical dimensions of the regenerator would have to be increased, a considerable saving in horsepower for the combustion air blower can be made. In the over-all picture an economic balance must be worked out between initial cost and operating cost with the local cost of energy being of particular importance.

In larger installations there is a tendency for operating cost to be of relatively greater importance. Of the Orthoflow A units currently in design or operation the size range has generally been between 2000 and 10,000 bbl per day of fresh feed input. The Orthoflow B arrangement has been employed for units of greater capacity, the largest now being built having a fresh feed capacity of 28,000 bbl per day with a reactor throughput of 45,000 bbl per day. It must be pointed out that these figures do not represent a maximum restricted by design limitations, as engineering studies have demonstrated that much larger units can be built without encountering unduly difficult engineering problems and without violating Orthoflow principles.

Especially with respect to its simplified design and ease with which it can be operated and maintained, the Orthoflow catalytic cracking unit is held in high regard by the refining industry and particularly by those who had experience with earlier types and place a proper value on dependability and continuity of performance.* * *

# T. C. C.

## *The moving-bed principle of design and operation employs both synthetic bead and natural clay catalysts*

THE first Airlift Thermofor Catalytic Cracking (TCC) unit was put on stream in October 1950 at the Beaumont, Texas, refinery of Magnolia Petroleum Company. Design and initial operation of this unit were described in detail in the April, 1951 issue of The Petroleum Engineer. As of February, 1954, twenty-eight Airlift units are in operation and an additional 18 are in various stages of design and construction. When completed, they will have a total cracking capacity well in excess of 500,000 bbl per day. Individual units vary in size from the smallest, designed for a feed rate of 1600 bbl per stream day and a carbon burning capacity of 1100 lb per hour, to the largest, designed for a feed rate of 28,000 bbl per stream day and a carbon burning capacity of 29,000 lb per hour. Between these sizes are numerous others designed to meet the requirements for capacity and product yields normally encountered in modern refinery operations.

The Airlift TCC unit and its predecessor, the bucket-elevator type TCC unit, both employ the moving bed principle invented and developed by the research and development and the engineering organizations of the Socony-Vacuum Oil Company and are licensed to the industry under patents of Socony. In the moving bed designs, the catalyst flows by gravity in a compact mass from surge hoppers at the top of the units through the reactor and regenerator to the low point in the systems where the flow is controlled and where it discharges into suitable equipment for elevating it to surge hoppers to complete the cycle.

As the names indicate, the bucket-elevator TCC unit employs mechanical elevators to circulate the catalyst while the Airlift TCC unit uses a pneumatic lift for such purpose.

All advantages of the TCC moving-bed system are inherent in both bucket-elevator and Airlift TCC units, such as:

1. High liquid recovery
2. High cracking efficiency
3. High equilibrium catalyst activity
4. Superior contacting of catalyst and reactants
5. Ease of operation because of relatively high catalyst inventory in system acting as a "fly-wheel"
6. High gasoline to coke ratio

Fig. 1 is a simplified flowsheet of the Airlift TCC process. Main parts of the catalytic system are the reactor, kiln, and airlift. Air for lifting is supplied by a low-pressure centrifugal blower to the lift pot at the bottom of the system in the form of primary and secondary lift air. Temperature of the primary lift air may be controlled by an air line burner and the pressure required at the lift pot is only 2 psig. The secondary lift air

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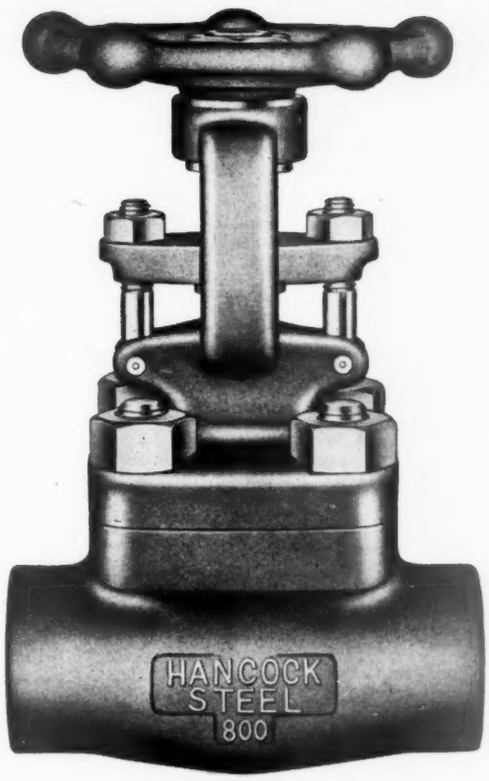


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serve to push the catalyst at a uniform rate into the primary air stream. This arrangement eliminates the need for catalyst control valves at any point in the system. The lift pipe is designed with taper so that proper velocities can be maintained throughout the entire length. In the surge hopper the catalyst is disengaged from the air and the catalyst operating level is maintained. Commercial lifts have been designed for rates of up to 500 tons per hour, although they are not limited to this capacity. The commercial design is based on several years of development on a laboratory and full-scale basis. Commercial operation has been entirely satisfactory. With the latest improvements in disengaging equipment, a basis attrition rate of about 0.7 tons per day per 100 tons per hour of circulation is obtained with bead catalyst. For a 15,000 bbl unit with 350 tons per hour circulation, this is equivalent to 0.3 lb per barrel of charge.

One of the important features of TCC moving-bed systems involves having the catalyst flow from the surge hopper at atmospheric pressure into the top of the reactor at 15 psig maximum through a seal leg. Steam introduced at the base of this leg flows countercurrent to the catalyst and prevents the escape of vapors to the hopper. The seal leg is tapered for uniform pressure drop and its length determines the maximum operating pressure. Actual operating pressure depends on pressure drop through the reactor and the recovery system. With the gas accumulator at 0 psig the reactor outlet will be on the order of 6 psig and the top of the reactor will be 9-13 psig. Fig. 1 indicates the reactor arrangement for a combined vapor and liquid feed unit wherein a part of the catalyst flows through pipes around the wall of the vessel and serves to maintain a fixed bed level while the main stream of catalyst flows as a falling curtain in the center. The liquid feed enters through a nozzle and sprays on the catalyst surface within the falling curtain of catalyst while the vapor enters above the catalyst and passes down through it.

For a vapor feed reactor the liquid nozzle and catalyst curtain system are omitted and the catalyst is uniformly distributed over the reactor area. All vapor feed reactors may be easily converted to liquid feed operation and liquid feed reactors may be operated on vapor alone. Oil vapors and catalyst pass concurrently through the reactor where excellent contact of oil vapors and catalyst is maintained at all points by virtue of the moving-bed system. In the bottom the vapors are disengaged by a series of disengaging channels into a plenum chamber where they leave the reactor. The catalyst is purged with steam that flows countercurrent to catalyst into the reactor effluent stream. This countercurrent stripping is designed to give substantially complete removal of hydrocarbon from the spent catalyst.

The TCC Airlift kiln is circular in design and, as indicated in Fig. 1, has a hole in the center through which the lift pipe passes. Spent catalyst enters through several pipes and is distributed uniformly over the kiln area. Combustion air at about 2 psig is introduced through a header box at the top of the kiln down through pipes subtended from the box and out into the center of the bed. Part of the air passes up countercurrent to the catalyst flow and out the top flue gas stack.

The quantity of this air is controlled by a back pressure regulator in the upper stack. The balance of the air passes down with the catalyst, over the cooling coils, through a disengaging channel and out of the system through the lower stack. The maximum temperature in the kiln is limited to 1350 F to avoid damage to the catalyst and to the kiln internals. Since a large part of the heat of combustion of the carbon must be absorbed by the catalyst and flue gas, the use of cold air generally results in maximum carbon burning capacity. With the maximum catalyst temperature of 1350 F and by the use of cold combustion air, the first airlift

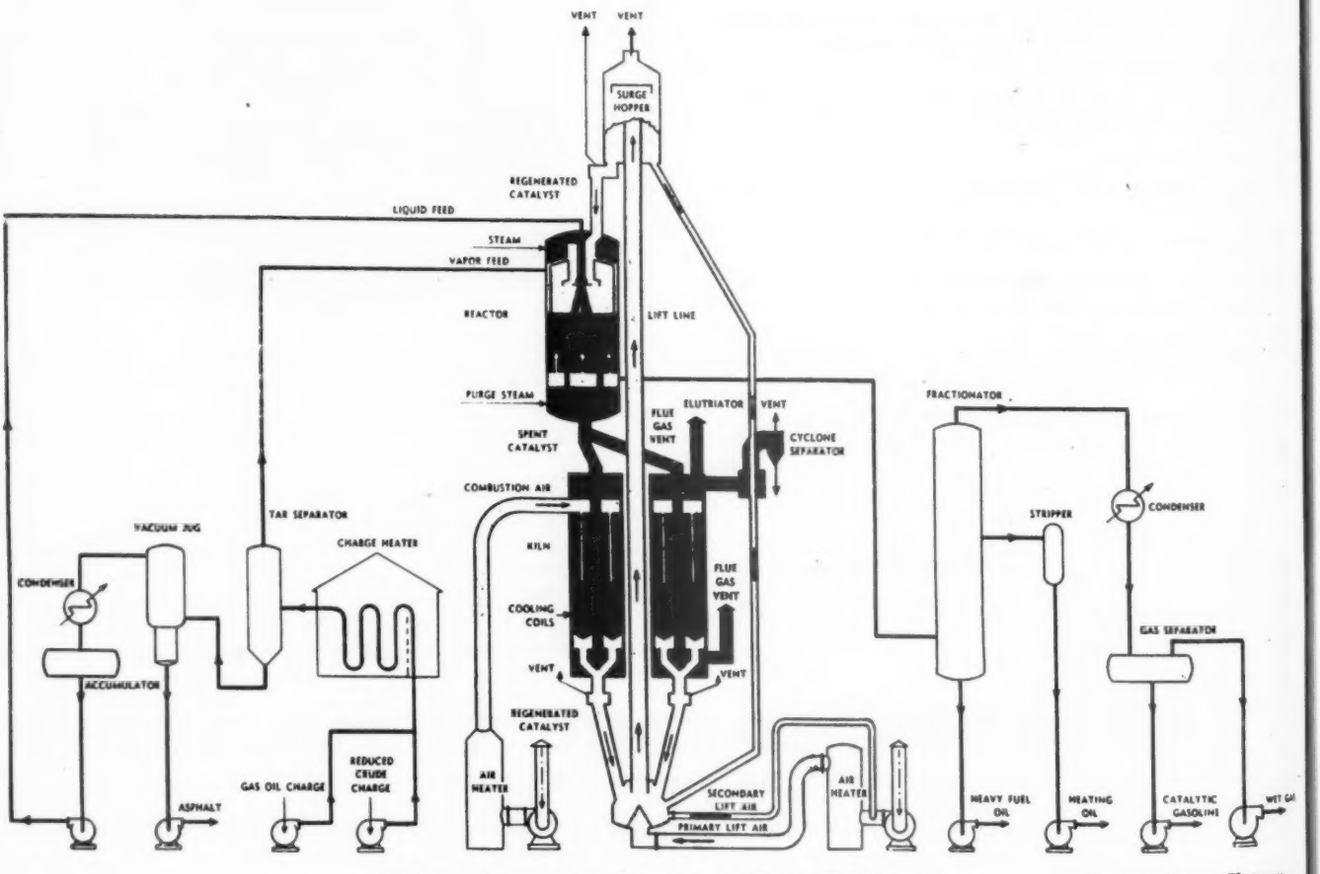


**FIG. 1. Diagrammatic flowchart of Airlift TCC Process.** — *Courtesy Socony-Vacuum.*

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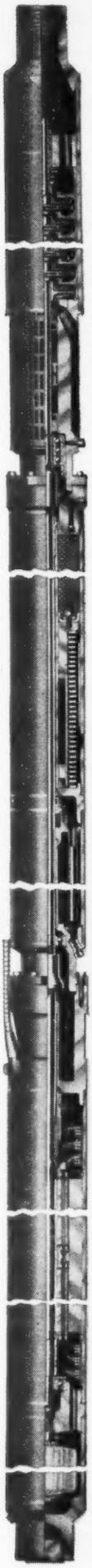

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units could be designed to remove 1 per cent by weight of coke deposit from the catalyst. The cooling coils in the lower part of the kiln also control the temperature of the catalyst to the reactor. External manifolding permits various combinations of coils to be placed in service so that adequate temperature control is available. On most units the steam drum is located above the kiln and a thermo-syphon system is installed. Below the kiln the catalyst flows through a metering box which is at atmospheric pressure and then into a short seal leg which feeds the lift pot on the same principle as the seal leg which feeds catalyst to the reactor.

The original Airflow TCC units exceed design charge throughput shortly after going on stream. Catalyst circulation and carbon burnoff in excess of design have also been attained. More recently, small improvements in kiln internals have reduced temperature variations so that a higher average burning temperature is possible while maintaining the same limit on maximum temperature. As a result, by making minor additions to the kiln and taking advantage of reactor throughput and catalyst circulating capacity already available, existing units may be operated at approximately 30 per cent above design. Similarly, the investment for any new installation will be reduced by taking advantage of these same factors.

Both synthetic bead catalyst and natural clay catalyst are being used in Airlift TCC units with the former more generally accepted. Synthetic bead catalyst was developed and is supplied by Socony-Vacuum Oil Company. This material is also manufactured and marketed by Kali-Chemie A.G. of Germany under license from Socony. The bead catalyst is silica-alumina to which a small percentage of chromic oxide has been added for purposes of improving regeneration characteristics. It is manufactured in the form of small spheres with a particle size range of 4 to 8 mesh. Activity index of fresh catalyst is 34 by the CAT-A method and this reaches an equilibrium value of 28-30 in the unit.

The Airlift TCC unit is designed to charge a wide range of stocks from any type of crude. In many cases the charge to catalytic cracking is the fraction above kerosine to asphalt although Airlift units have been designed and operate equally well on heavier gas oils as well as wider fractions which contain heavy naphtha. In this latter operation, an octane lift of as high as 15-20 units on the naphtha fraction has been realized. Also, good cracking results are obtained on the kerosine when included in the feed. Other charge stocks include whole crude above asphalt, coker and visbreaker gas oils or full range distillates, solvent deasphalting raffinates and extracts from solvent lube operations. Heavy gas oil above heating oil or full range gas oil above gasoline may be recycled in whatever ratio refinery economics indicate is desirable.

Equipment for feed preparation is conventional and the system indicated in Fig. 1 will handle any of the charge stocks enumerated above. Charge is heated by exchange and fired heat and flashed at 775-825 F and 15-20 psig in a tar separator to provide a vapor feed. The tar separator bottoms may be fed to the TCC as liquid feed if the unit charge is a distillate stock or flashed in a relatively small vacuum jug to provide a liquid feed overhead if the unit charge is an asphalt-bearing stock.

As indicated in the previous discussion, the feed preparation and fractionation and the catalyst circulation systems of the unit are independent of each other. Inlet, outlet, and bypass valves at the reactor permit operation of the feed preparation system without catalyst circulation. Although oil charge rate and temperature may be considered control variables, these are generally fixed by charge stock availability and capacity of the feed preparation system and severity of operation is controlled by catalyst circulation and temperature. In this connection it will be recalled from previous discussions that the cooling coils in the kiln permit control of catalyst temperature independent of catalyst circulation rate. These independent variables—oil charge rate and temperature, catalyst circulation, catalyst temperature and recycle ratio — result in wide flexibility in charge stocks and in products while obtaining maximum utilization of available equipment.

As the design of the Airlift TCC unit did not introduce any basic changes in the operating conditions for the major vessels, no problems of a construction or maintenance nature have been encountered. Although initial operation of the lift system indicated critical localized areas where erosion occurred at a more rapid rate than could be predicted from laboratory studies, minor design changes, together with selection of the proper materials of construction, have eleminated this as a maintenance problem. As built today, the Airlift TCC unit may be expected to have the same high stream efficiency and low maintenance associated wtih earlier models of the TCC process. * * *

# Fluid Cat Cracking

*Advantages of this type of cracking have been proved in both war and peace-time operations*

J. G. ECKHOUSE* and W. A. KEIGHTLEY*

THE UOP fluid catalytic cracking process is a high temperature and low pressure catalytic cracking process employing the fluid technique to circulate catalyst. It is employed primarily to convert distillate oils into high octane gasoline and to reduce the overall refinery fuel oil production.

The process has undergone continued development since its first introduction in 1943, and current designs are noted for their simplicity, and ease of operation as well as low operating and investment costs, with optimum product distribution.

### Fresh Feed

This process is capable of cracking a wide variety of stocks from all types of crude sources. Typical stocks may be either virgin or cracked and may include naphtha, kerosine, light gas oils, wax distillates, atmospheric and vacuum heavy gas oils, and distillates from viscosity breaking or coking.

Naphtha, say of a range 302-428 F, may be fed to a fluid catalytic cracking unit either alone or mixed with heavier material. One of the UOP units has processed up to 15 per cent straight run naphtha in the feed. The benefits found are the removal of mercaptan, sulfide, and disulfide sulphur, which removal increases the lead susceptibility of the naphtha. Improvement of naphtha under cracking conditions set for heavier and less refractory stock will be slight. This applies regardless of the process as long as

*Universal Oil Products Company.

catalyst of similar composition is used. Normally, we feel that little advantage is gained by charging any fractions boiling below about 475 F. If charged alone at more nearly optimum conditions, naphthas will be upgraded to the extent that front end volatility is improved and hence some octane improvement results. One plant has been designed and operated with a second fluidized reactor to desulfurize virgin naphthas and kersosine fluid catalytically.

The heavier stocks are better charging stocks. The only limitations on these stocks are Conradson carbon and metal contaminants content. The effect of increased Conradson carbon is to form increased catalyst deposit. Thus if the burning capacity of the regenerator is not limiting, 0.5 to 0.75 per cent Conradson carbon values or higher may be tolerated, but normally we expect the figure not to exceed 0.25 per cent. The Conradson carbon increases as the vacuum bottoms are further reduced to supply heavier vacuum gas oil charging stock. Normally when producing vacuum bottoms of 100 penetration, the vacuum gas oil overhead from the vacuum distillation column is a permissible feed stock.

Metal contaminants likewise increase as more of the vacuum bottoms are utilized. Metal contaminants do not normally deactivate the catalyst but are detrimental due to the change in product distribution which is evidenced by more gas production at the expense of gasoline. Metal contaminants vary with different crudes. The latest UOP vacuum unit design tends to reduce metal contaminants to a minimum, whereas propane deasphalting as a feed preparation process seems to result in higher metal concentrations. We suggest the following maximum toleration:

| | |
|---|---|
| Iron | not to exceed 1.00 parts per million |
| Vanadium | not to exceed 0.40 parts per million |
| Nickel | not to exceed 0.15 parts per million |
| Copper | not to exceed 0.10 parts per million |

Distillates produced from vis breaking operations are satisfactory from a Conradson carbon standpoint but as they have been partially dehydrogenated in the viscosity breaking operation, they can be expected to give more coke for a given conversion.

### Feed Preparation

Vacuum distillation is generally favored for preparation of heavy feed stocks from reduced crudes.

While a propane deasphalting unit may give slightly more FCC charging stock than a vacuum unit, its operation is generally more expensive; hence it is seldom that any extra quantity of charging stock can be justified economically, particularly as it may leave more detrimental metal contaminants in the charging stock than vacuum distillation.

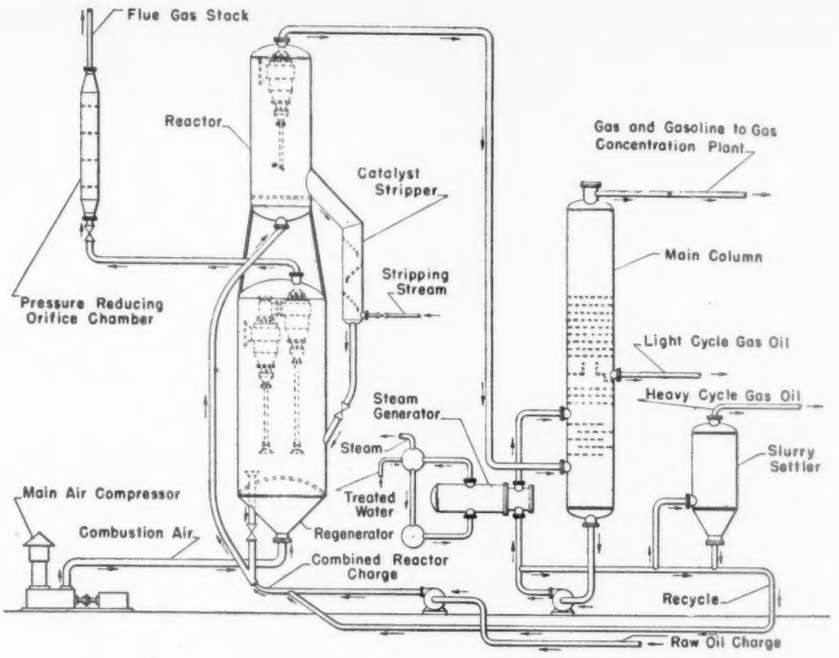


**FIG. 1. Typical flow diagram of a UOP fluid catalytic cracking unit.**

### Description of Process

The attached sketch shows a typical flow diagram for a 5000 B/SD unit.

The gas oil feed, cold or hot, is charged together with recycle into the hot regenerated catalyst stream, is vaporized, and passes to the reactor where the reaction is completed. The vapors from the reactor, carrying some catalyst, pass upward through the reactor cyclone separator, which removes most of the entrained catalyst, and into the fractionating column.

The spent or used catalyst passes downward from the reactor through the steam stripper and enters the regenerator where the carbon deposit is burned therefrom. Oxygen for combustion is supplied by air from the air blower. The flue gases carrying some catalyst pass upward through the regenerator cyclone separators where entrained catalyst is removed and pressure is released in a pressure reducing chamber which serves as a noise eliminator. The regenerated catalyst again enters the incoming gas oil charge stream to repeat the cycle.

For a typical unit of this capacity the "single vessel" type (reactor superimposed upon the regenerator) is used.

No external heater is necessary with this unit since it is of the heat balance type. The initial heat to bring the unit on stream is supplied by the direct-fired air preheater and torch oil in the regenerator.

The fractionating column is, in general, conventional, with gasoline taken overhead and one or more selected fractions withdrawn as sidecuts. The net column bottoms are sent to storage via the slurry settler. Steam may be generated by recovery of heat in the fractionator column bottoms. Catalyst-containing oil from the bottom of the slurry settler is returned to the reactor with the fresh feed and may amount to from 2 to 10 per cent of the fresh feed.

The unstabilized gasoline and gas from the low pressure receiver pass to the gas fractionation section for debutanization and recovery of $C_3$-$C_4$ polymerization unit feed.

The fresh feed capacity of a catalytic cracker, in general, depends upon the conversion, combined feed ratio, and the coke burning capacity of the regenerator. What the capacity will be by changing these variables can be determined best in an operating plant, but it can be calculated closely.

### Catalyst Inventory

The total catalyst inventory of a 5000 B/SD unit, burning around 4233 lb/hr of coke, at 53 per cent conversion, is about 37 long tons.

The UOP regenerator design is set up for optimum pressure to increase the coke burning rate (pounds of coke burned per hour per pound of catalyst inventory in the regenerator) and the regenerator is therefore, reduced in

size, which reduction in turn reduces the catalyst inventory in the unit. Thus catalyst replacement rate expressed in pounds/barrel required to maintain a given catalyst activity is low.

### Catalyst Losses and Consumption

A distinction should be made between losses and consumption. Losses are a function of design and occur largely as entrainment in the flue gases from the regenerator. With the proper velocity in the regenerator, a small catalyst inventory, and two-stage cyclone separators of the proper design, the catalyst loss at 53 per cent conversion will not exceed 0.25 lb per bbl of fresh feed and for 70 per cent conversion will not exceed 0.40 lb per bbl.

This rate of catalyst makeup is usually about that required to keep up the catalyst activity and is normally within specifications set forth by any local laws.

Catalyst consumption includes the above described losses plus extra catalyst makeup necessary to compensate for loss of catalyst activity, metal contamination, etc.

### Effect of Regenerator Pressure

Because of more efficient coke burning, as well as other design considerations, the regenerator pressure has been progressively increased to provide a lower cost unit when considering both unit and operating costs. Rather than burn coke at atmospheric pressure, which requires large equipment and large catalyst inventory, with accompanying large catalyst losses, we have increased the pressure on the regenerator, which improves and accelerates the burning by raising the oxygen partial pressure. This reduces the cross section of the regenerator to less than 40 per cent of that required for an atmospheric pressure regenerator with consequent savings in plant costs for both the regenerator and the reactor. At the same time the catalyst inventory is reduced which, in turn, reduces both catalyst losses and catalyst withdrawal requirements for activity maintenance.

However, while plant costs, catalyst inventory, and catalyst consumption are reduced by increased regenerator pressure, a higher pressure blower is needed. This requires more horse power than is required for atmospheric burning, but this increase is more than offset by the above advantages. In addition, savings are made on the gas concentration compressors, which will be reduced in size because of higher pressure of FCC distillate receiver.

### Heat Balance Unit

UOP FCC units are heat balanced. To establish heat balance the catalyst circulation is such that all heat necessary to preheat the fresh feed and maintain reactor temperature is supplied by the catalyst regeneration. To the extent necessary, heat is removed from the recycle by a column bottoms steam generator. The resulting rather high catalyst-to-oil ratio is desirable for good product distribution.

The UOP FCC process is able to utilize a greater portion of the heat formed from the combustion of coke to preheat the fresh feed to the reactor than other processes, since the catalyst and oil feed are intimately mixed. In addition, part of the heat in the flue gas can be recovered in a waste heat boiler, if desired. This process provides for very efficient utilization of the heat of combustion without intermediate heat carrying mechanisms. Approximate utilization of heat is:

| | Per cent of total heat of combustion |
|---|---|
| Heat transferred directly to fresh feed..... | 75 |
| Heat recovered as steam in waste heat boiler. | 15 |
| Heat losses (flue gas, radiation, etc.)..... | 10 |
| | 100 |

This direct transfer of heat permits this process to operate on a totally liquid charge. It is thus unnecessary to provide an outside heater on the fresh feed to operate the unit and no catalyst coolers are necessary and it is not necessary to supply any portion of the feed as vapor.

### Catalyst-to-Oil-Ratio

As previously mentioned, the rather high catalyst-to-oil ratio of heat balance units is desirable for good product distribution. This catalyst-to-oil ratio may be 10:1 or higher. Lower ratios require markedly lower reactor temperatures and longer residence time, resulting in higher catalyst inventory, lower gasoline octane number and lower olefinicity of the $C_4$ and lighter gases, which latter means relatively less potential polymer.

With low catalyst-to-oil ratio a fired feed preheater is necessary and, in turn, this extra heat must be removed

### Processing of Liquid Feed

The ability to process a totally liquid feed is one outstanding advantage of the FCC process, since charging stocks are becoming heavier because of the removal of valuable virgin light distillates for other purposes. No change in design is required for variation of the charging stock boiling range

The advantages of liquid feed include utilization of the heat of combustion of coke directly to supply latent and sensible heat to the feed without a fired preheater. The liquid feed can come from storage rather than directly from the feed preparation unit permitting several days' storage for FCC charge. This means that the FCC unit can operate independently of feed preparation units. A FCC unit that uses liquid feed also has the advantage of permitting the use of a vacuum feed preparation unit to produce heavier and increased quantities of feed from reduced crude. This material cannot be vaporized at atmospheric or higher pressures since destruc-


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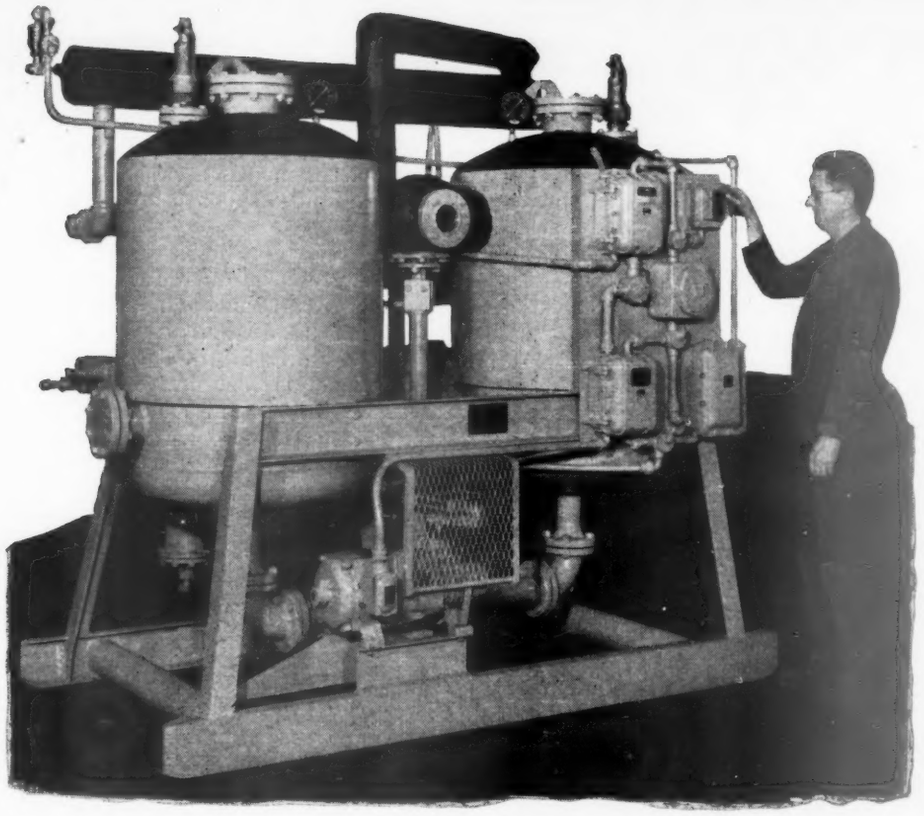

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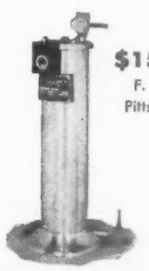

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tive reactions occur at temperatures below its boiling point which result in coking of the heater tubes and transfer lines.

### Yields

Typical yields from a UOP Fluid Catalytic Cracking unit when cracking a 31 deg API Mid-Continent gas oil, over silica-alumina catalyst, in once-through and recycle operations, are as follows:

| Operation | Once through | Recycle |
|---|---|---|
| Conversion | 60 | 75 |
| Yields, (volume per cent) | | |
| Debutanized gasoline | 45.0 | 53.0 |
| Cycle stocks | 40.0 | 25.0 |
| Butylenes | 5.8 | 7.1 |
| Butanes | 8.7 | 9.4 |
| Propylene | 5.2 | 6.4 |
| Propane | 2.4 | 3.3 |
| $C_2$ and lighter gas, wt. % | 2.5 | 3.1 |
| Octanes 10 lb RVP gasoline | | |
| Motor method (F-2) clear | 81.8 | 81.8 |
| +3cc TEL | 86.8 | 87.4 |
| Research method (F-1) clear | 93.7 | 94.2 |
| +3cc TEL | 98.7 | 99.1 |
| Yields with polymerization (vol. %) | | |
| 10 lb. RVP polymer gasoline | 8.0 | 9.9 |
| 10 lb RVP catalytic gasoline | 47.4 | 55.8 |
| Total 10 lb RVP gasoline | 55.4 | 65.7 |

### Mechanical Design

UOP has developed, for simplicity and clean design of circulation lines, the reactor-on-top design, which eliminates regenerator riser and places all major controls close to ground level. With this arrangement in pressure balance, the regenerator pressure is higher than the reactor pressure which is advantageous both for coke burning and the process reaction.

The fluid principle lends itself to an operation wherein catalyst flows either in the dense or dilute phase through properly designed lines. In the UOP FCC process the catalyst is lifted only by the raw oil charge.

Accordingly, this design has advantages as follows:

1. Low catalyst inventory
2. Lower catalyst losses
3. Minimum air required for combustion plus air lift
4. Elevated catalyst hopper eliminated.
5. Reactor and regenerator are not complicated with a multiplicity of internals such as lift pipes, cooling coils, collecting grids, disengaging channels, etc.

### On-Stream Time

The reliability of UOP FCC designs is demonstrated by the long runs obtained. Runs of 400-500 days are common, which accounts for the high percentage of time on stream. A review of on-stream efficiencies reveals that 20 post war UOP units of the type under discussion show 96-98 per cent operating efficiency. The difference in on-stream efficiency times can be evaluated. For a 5000 B/SD unit an additional 5 per cent on-stream efficiency is equivalent to an increase of fresh feed capacity of 53,500 bbl per year. Assuming the marginal operating profit as $0.50 to $1.00 per barrel, this extra capacity means increased earnings of from $26,500 to $53,000 per year.

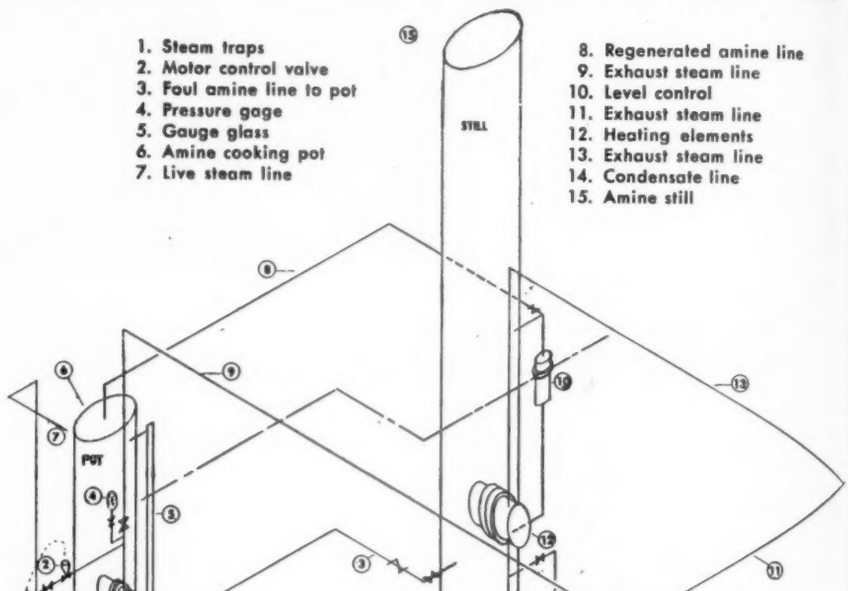
### Estimated Operating Costs

Operating costs will vary, of course, with the size of the unit. For a 5000 B/SD such as has been discussed here, operating costs for the FCC unit together with a gas concentration unit for recovery of light gases and stabilization of the gasoline will run about 44c per bbl of feed. This figure includes supervision, labor, utilities, maintenance, laboratory, catalyst, royalty, refinery and administrative overhead, taxes, insurance, amortization and interest.

### Commercial Installations

At the present time there are nearly 60 UOP fluid catalytic cracking units in operation or under construction. These represent a total design feed capacity of over 400,000 bbl per day, and sizes ranging from 1400 to approximately 35,000 bbl fresh charge per day. * * *

## PLANT AID




## Amine Reclaimer[1]

GEORGE ZORNS[2]

*Purpose:* To keep amine solution clean.

*Description:* The general method of cleaning amine solution is to periodically set a "pig" at the treater and operate this "pig" until the solution is clear. This "pig" requires numerous controls and a considerable amount of piping.

The reclaimer we have in operation at this plant is permanent and is in continuous operation. The operation requires a minimum of attention and is keeping the amine solution in good shape. This reclaimer has *one* control and that is not a necessity. In general all control will be given by the still controls.

The reclaimer is set so that its level is maintained by the treater still level control. The feed comes out of the still bottom through a merco and good check valve. The steam to the heating element is exhaust steam which is taken downstream of the meter on the steam to treater still line. This causes the reclaimer to operate at the same temperature as the still and prevents cracking of the amine.

When the reclaimer is full (10 days), the feed is cut off and the exhaust steam is shut off. Live steam is turned into the element and is controlled by a pressure control and motor valve. When the reclaimer liquid is cooked down, condensate is used to fill it back to the original levels. When it is again cooked off the residual is dumped through a valve in the bottom of the reclaimer.

This vessel is very inexpensive and is giving excellent service.

[1]Class C, second prize at NGAA—Permian Basin regional meeting.

[2]Chief operator, Phillips Petroleum Company, Hobbs (New Mexico) plant.

# Cooling Tower Development Based on Continuous Research

*Each phase of design is studied in pilot plant units to determine improved construction principles*

J. M. WHITESELL

THE role of cooling tower development is of major importance in this day of rapid industrial expansion, for this expansion is accompanied by an enormous water conservation problem that is expected to grow in an ever increasing spiral. Huge quantities of water are wasted each year by a one-pass method of heat dissipation, and the cooling tower is being used more and more as the answer to this problem.

Industrial growth as well as a general change in the severity of cooling conditions has been experienced in power, petroleum, chemical, steel, and allied industries. Cooling towers have not only been subjected to larger and larger cooling loads but are being used in an ever widening variety of cooling and mass exchange problems. This means that the manufacturer may no longer rely on stock designs and shelf items to satisfy demands.

With this problem confronting industry it is increasingly important that more and more detailed knowledge of large scale operations and performance be developed by individual manufacturers. The cooling tower is the largest piece of commercial heat transfer equipment used by man; and accordingly it is essential that repeated reviews of design, performance, costs, and materials be continually made. It is suggested that more details of performance and underlying engineering problems be made more generally known if a greater understanding of tower control and maintenance as well as optimum selection of equipment is to be achieved.

**This article summarizes in comprehensive fashion the state of progress in cooling tower design and the methods for research into the principles governing cooling tower operation. It shows the method employed and the equipment used in the study of these numerous phases of tower design and is typical of the present state of research in this field.—Editor.**

### Published Data

In the early development of cooling towers there was little uniformity in procedure for correlation of experimental data. The correlations might well have been called experience factors rather than theoretical analysis as applied to test work. As the mechanical draft era came more strongly to the front, this problem become more acute. The early work of Merkel[1] made a lasting impression on industry and laid the foundation for analysis of the thermodynamics of transfer in the tower This approach to data analysis and correlation is one if not the most accepted method throughout the world. With a positive method of correlating and interpreting data, it is then merely a problem of having adequate research and development facilities to produce reliable data and superior equipment.

As an aid to general knowledge, periodical and text publications have from time to time offered some cooling performance data on a variety of tower packings. The majority of this data was obtained from small pilot plant type installations where the cooling performance was the prime objective. Seldom has reliable pressure drop data been recorded. Serious misconcept of value may be obtained by this approach, as many other factors can be of equal importance in determining the merits of packing for industrial towers.

### Experimental Facilities

The installation needed by the full scale researcher or the cooling tower manufacturer for development purposes must be reasonably comparable in size to industrial units. Pilot plant towers frequently reported on in the literature have approximately one-two hundredth (1/200) of the plan area of the larger single cell industrial cooling towers. The differences in effective heights of cooling are also quite large. The tremendous sizes to which cooling towers have grown has created a need for pilot plant stages seldom if ever realized in other similar pieces of equipment. There have been numerous procedures used to circumvent these required pilot stages, but the most reliable method of minimizing the size scale effect is to do all final stage testing on large scale equipment.

One or more of the following procedures has normally been used for obtaining basic cooling tower performance data:

1. *Use a small pilot plant tower that is comparatively inexpensive in first cost and operation. A projection of data must, however, be made if it is intended to be used for the design of full scale equipment. Such an installation is shown in Fig. 1. This unit is 2 ft 6 in. by 2 ft 6 in. by 9 ft high and is completely equipped with automatic recording instruments for measurement of all temperature and flow rates. Packing changes and test runs for various loadings can be made rapidly.*
2. *Test commercial installations in*

**The Author**

J. M. Whitesell is chief engineer of the heat exchange equipment section for The Fluor Corporation's products division. He joined Fluor in 1947. BE and MS degrees in chemical engineering were received from the University of Southern California. Service prior to that at Fluor was with the Standard Oil Company, El Segundo as well as the University teaching staff.

EXCLUSIVE

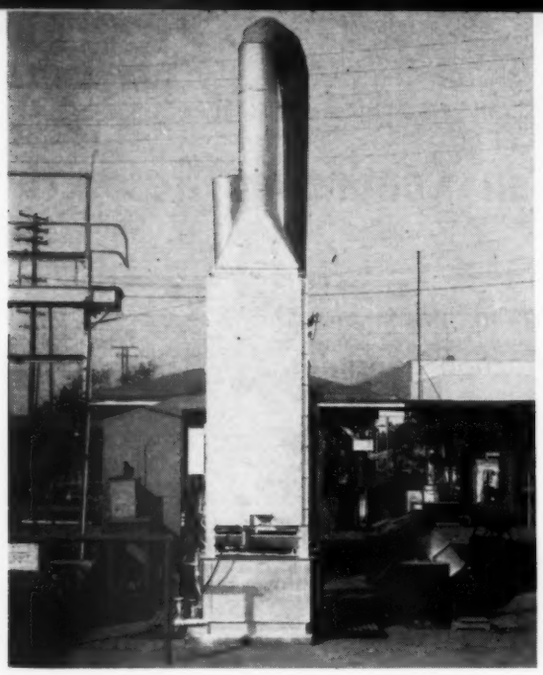


**FIG. 1. Pilot plant cooling tower used for basic research on evaporative water cooling and completely equipped with recording instrumentation.**

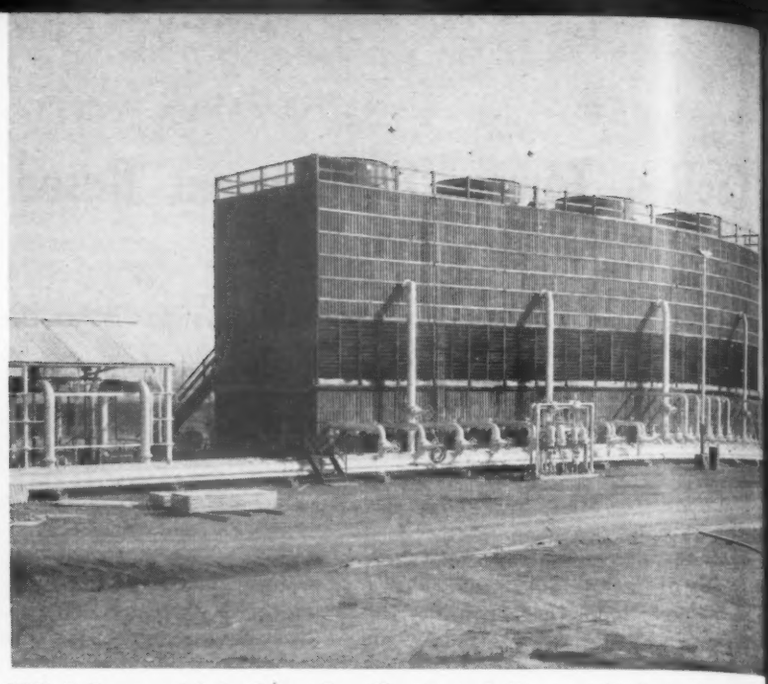


**FIG. 2. Commercial-size four-cell cooling tower built over a "coil shed" in which are installed atmospheric heat exchange sections.**

*the field that will give full scale data, but require coordination with plant cooling requirements and is severely limited to narrow ranges of experimental conditions. This arrangement is economical but difficult to coordinate; the range and therefore general reliability of data is not above question. Fig. 2.*

3. *Use a full scale experimental tower. This unit should be completely independent of other incumbrances, capable of handling wide ranges of design conditions and physical changes. A unit of this type is expensive in first cost and operation but is the most rapid and reliable in results. Such an installation is shown in Fig. 3. The larger structure is 18 ft by 18 ft by 45 ft high with a 10 ft diameter fan. The tower is of standard design, but the water distributing system may be operated at any one of six elevations varying from 16 ft to 36 ft above the basin. Different types of distributing systems, decking, fans, and drift eliminators may be tested with ease. Two speed motors driving an adjustable pitch fan as well as two separate pumping units allow an extreme range of water and air rates for testing. A fired tube type water heater with a capacity of 20,000,000 BTU/hr provides a more than adequate heat load. Natural gas as well as LPG standby allow uninterrupted testing the year around. Recording, indicating, and control instruments for flow rates, temperatures, and pressures are all brought to a central control panel for convenience and efficiency.*

Each of these procedures will provide basic data from which one may derive performance data, make economic studies, and select superior equipment. The optimum approach to this problem, however, is to have both the small pilot plant tower and the full scale development installation so that optimum means of cooling may be rapidly derived from the multitude of possible combinations of tower components.

An experimental unit being used for final development on cooling towers should be large enough that data obtained may be used directly on commercial installations. This unit should be operated entirely independent of the small pilot plant size tower. The large tower is primarily involved in the development of superior cooling performance; but is also used experimentally to tie together the overall aspects of pressure drop, air flow characteristics, drift removal, fan performance,

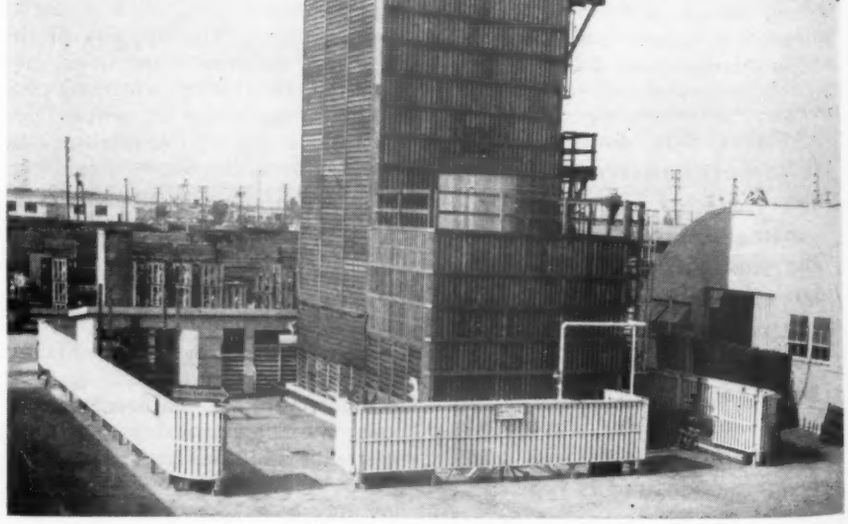


**FIG. 3. Extremely wide ranges of operating conditions and tower size as well as modifications may be easily studied in this full-scale experimental cooling tower.**

gears, couplings, erection problems, and cost. The two cooling tower cells shown in Fig. 3 are engaged in work on entirely different problems, yet both are tied into the same heat, control, and recording equipment.

### Packing Development

"Packing" or "Filling" may be considered the heart of the cooling tower, for it is here that the critical problems of heat exchange are encountered. In a normal cooling tower of large size, upwards of 50 per cent of the total quantity of lumber may be used to perform the duty of providing surface and repeated breakup of water. It would be unjust to name one type of packing superior to all others in all ranges of performance. With virtually unlimited types, shapes, arrangements, and materials of construction, the universally optimum packing will probably never be developed. As long as new materials of construction are brought forth, costs fluctuate, knowledge increases, and ideas are born, there will always be a better combination. It is for these very reasons that adequate development equipment must be maintained by the manufacturer.

The development of a superior packing is an interesting and painstaking engineering task. On a proposed type of packing it is necessary that full scale data be developed on performance, pressure drop, fabrication, and erection problems. It is obviously insufficient to merely propose that a new type of grid be used in packing. The change must be economically justified after sufficient data have been developed to insure optimum wood dimensions, vertical spacing, and horizontal spacing. These data must then be balanced against packing cost, pressure drop, support cost, tower shell cost, and erection cost. Consideration must also be given to whether the resultant cooling tower is to be designed on the basis of first cost or payout period where power (a function of pumping head and air horsepower) is an important factor. Finally, and in some respects most important, the design is given certain limitations by the manufacturer's policy wherein the packing should be of rugged construction providing long and trouble-free life in service.

### Drift Eliminator Development

The removal of water droplets from the exit air stream of a cooling tower constitutes another interesting engineering and development problem. The volume of air passing through the cooling tower packing picks up water droplets which must be removed before being discharged back into the atmosphere. Drift eliminators normally consist of slats arranged so as to provide a tortuous path for the exit air stream. These nuisance droplets of water impact on the eliminator forming a film that falls back into the tower. This feature of cooling towers is frequently given minor engineering attention in comparison to the filling and other portions of the tower. Here again is an economic situation that demands a sound balance between drift removal ability, pressure drop, cost, and solidness of construction.

It is interesting to note that for years it has been standard practice to quote maximum drift loss at not more than 0.2 of 1 per cent design circulation rate, whereas a well designed drift eliminator will actually give performance that can be guaranteed as a value of 0.02 of 1 per cent.

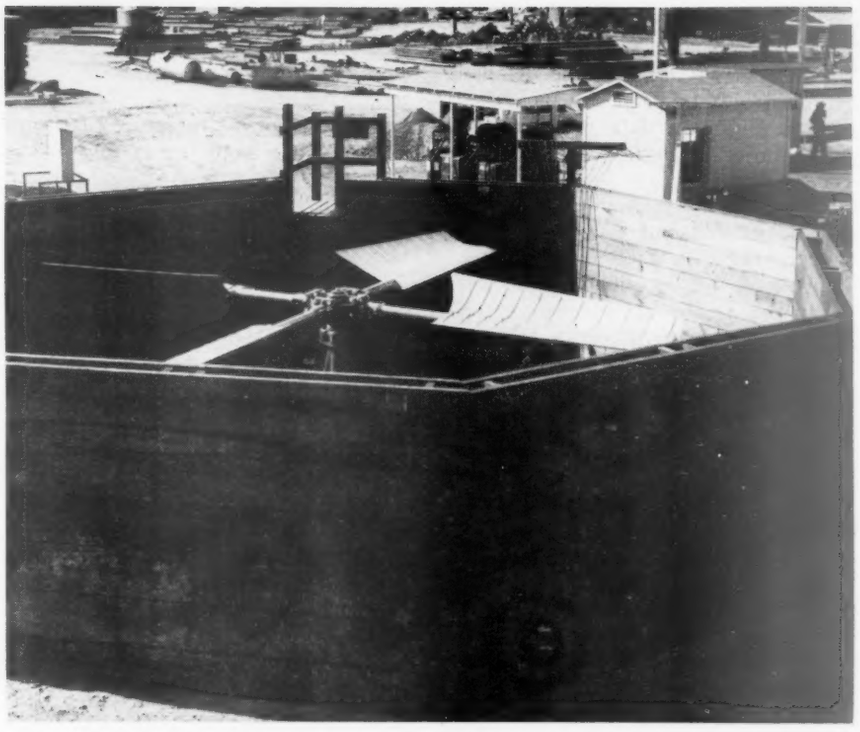


**FIG. 4. Mechanical draft fans are an important part of a cooling tower. This test stand enables researchers to study both static and dynamic principles of design of different fan components.**

### Cooling Tower Fans

As the rest of the cooling tower has developed throughout the years, so has the cooling tower fan. Some of the earlier models bore a striking resemblance to the common desk fan or aeroplane type propeller.

In few other fields of fan development have designers been confronted with more combined problems of corrosion, strength, fatigue, efficiency, sound level, and balance. Cooling tower fans have been built in many shapes and forms with all sorts of resultant efficiencies. These fans have for the most part been built in the more common industrial sizes form 8 to 20 ft in diameter; but for certain installations, they have been extended up to 38 ft in diameter.

As industrial cooling tower fans are normally designed for large delivery (100,000 to 800,000 cu ft per minute), for low static pressures (0.15 to 0.65 in $H_2O$), and considering that horsepower is a reasonably critical item in design, it is logical that the fan should be special for this service. It must be more than just a paddle wheel to move air; it must do the job efficiently and without excessive speeds. Preferably, a cooling tower manufacturer should produce his own fans or work very closely with the development program of a fan manufacturer.

Fans are normally rated by the NAFM-ASHVE or ASME Test Codes, which stipulate the procedure as well as the relations of either the duct or chamber test method. Unfortunately neither of these code tests conform to the operating conditions existing in any cooling tower. It is natural, therefore, that fans tested under one condition will not exactly perform in the same manner under an entirely different setup.

It is preferable that cooling tower fans be tested in a cooling tower or, at least, in a dimensionally and operationally similar setup. Cooling tower fans should also be produced in geometrically similar dimensions throughout their sized range. Once an efficient design has been produced, the same high level of performance may be maintained whether it be an 8 ft, 20 ft,



XUM

or 38 ft fan. One of the prime advantages of geometric similarity in fan design is that it requires the detailed testing of only one fan size which results in minimum data development, rating sheets, confusion, and possible error.

Cooling tower fans should also be duly considered and tested from the standpoint of critical vibration, stresses, sound level, fatigue, and balance; this work should also be done in a full scale development installation. Fig. 4.

During the early stages of development the cooling tower industry has been confronted with numerous cases of fan failures. Here again the proper answer to the problem is an adequate development program and staff to answer industrial needs.

### Cooling Tower Gears

Many problems confront the gear manufacturer when his equipment is assigned to the task of turning a low speed cooling tower fan in a moisture laden atmosphere. Unfortunately the maintenance servicing of gears in this application is frequently inadequate; this in turn must be compensated for by special design. Special seals for moisture, external air breather lines, external oil level check and fill lines, special positive non-failure lubrication pumps as required, special thrust bearings, sludge sumps, and corrosion considerations are all required in cooling tower gear service. Close association with gear manufacturers on these problems has resulted in special designs that today offer the purchaser significantly trouble-free service.

### Vibration Cutout Switches

Cooling tower engineering also has to cover its share of safety considerations. The vibration cutout switch is in some respects a hanger-on from the earlier mechanical draft cooling tower days where a large percentage of mechanical equipment failures occurred. This control switch is a safety measure which automatically switches off the power on a fan-motor-gear assembly that is vibrating excessively and/or has failed. This development feature is incorporated in the design to protect towers from major damage which might occur had a minor vibration been allowed to develop into a major failure. Even in this day of few mechanical failures, this device is certainly a feature worthy of inclusion in each and every installation. It is heartily supported by most operating and engineering personnel as a most economical form of insurance.

### Cooling Tower Panel Walls

It is seldom considered that the enclosure walls of a cooling tower constitute a major problem. Towers newly erected are truly an impressive piece of equipment in any plant; but if unsightly white water stains appear in the form of blotches, this piece of equipment becomes an ugly eyesore.

The fabrication of these massive walls of wood so they are leak and stain proof is certainly an important factor if the equipment is to be considered a quality product. The principle of fully ventilated interior panels that are water tight and an independent outer cover wall entirely separated from the inner wall seem to be the answer to long service without unsightly stains.

### Miscellaneous Features

There are many other miscellaneous features of cooling towers that require frequent reviewing for possible improvement. The distributing system consisting of the main header (or flume), side laterals, and nozzles provide the means of uniformly distributing the water throughout the tower area. If wooden flumes and laterals are used, it is essential that the construction be considered from the standpoint of long, trouble-free life. Even though low pressures are commonly experienced, it is considered justifiable to supply a heavy bolted wooden construction without nails. Where steel systems are used, standard heavy walled pipe and fittings should be specified in place of some of the less expensive methods of construction. Orifices in nozzles should be sufficiently large to pass most trash particles common in cooling tower waters. Even though screening of suction pit water is common practice, the nozzles may easily become clogged unless a pressure system is used or large nozzle orifices are specified. Some systems presently being used are extremely expensive from the standpoint of maintenance expenses. Poor distribution caused by clogged nozzles costs industry huge sums of money because of loss in performance as well as maintenance labor for cleanout. Others require complete replacement when repairs become necessary.

Fan efficiency and structural soundness are very important considerations of cooling tower mechanical equipment. It is also very important to provide for efficient means of air entrance to the fan. A highly efficient fan design might be conceived; but if this were to be used with an entrance throat of poor design, the gain might well be offset with an entrance loss resulting in overall mediocrity. The smooth venturi throat at the bottom of a fan stack is certainly a well justified item of cooling tower equipment. Only in small first cost installations where horsepower is not of prime importance is it considered that venturi throats are not justifiable. These smooth flow entrance throats are another sign of quality engineering in a cooling tower.

Structural design for unusually large wind, earthquake, dead, and live loading has resulted in certain methods of construction featuring trouble-free service over long years of service. Redwood timbers of selected heart lumber have proven life spans of more than thirty years in service in certain installations. Long life in cooling tower service is best insured by the use of solid bolted construction where at all possible. The use of nails for any supporting member is certainly frowned upon. The use of structural bracing methods allowing full values for compression and tension are worthy of inclusion in specifications. Internal gusset plate construction common in other fields of construction has improved cooling tower structures by minimizing braces, yet actually increasing the loading capacity.

The quality or grade of lumber used throughout the cooling tower structure should not be overlooked. A structure that includes the poorer grades of redwood can only be placed in the bracket of a false economy tower. The severe conditions of the water normally used in a cooling tower demands good materials of construction. Although redwood is considered by all to be highly resistant to the conditions existing in cooling tower service, it is only the interior portion of the massive redwood logs that has qualifications for this duty.

### Conclusion

The modern cooling tower has seen considerable development since man first attempted to increase the rate of cooling in an open pond by means of a brush pile over which he circulated water. This was the first step toward the development of a piece of heat and mass transfer equipment which today has outgrown all other exchangers in size. Adequate full and pilot scale equipment must be maintained by each manufacturer if the cooling industry is to maintain its present high level of development and continue to advance.

"True Economy" in cooling towers cannot be too strongly stressed, for it is not too difficult to build an inexpensive tower. Real value may only be gathered by a detailed analysis of all the tangible and intangible aspects of the equipment. True economy cooling towers are developed by intimate contact with field conditions, requirements, and development equipment. With such organization it is not too difficult to build equipment which will promote the faith of the ultimate customer.

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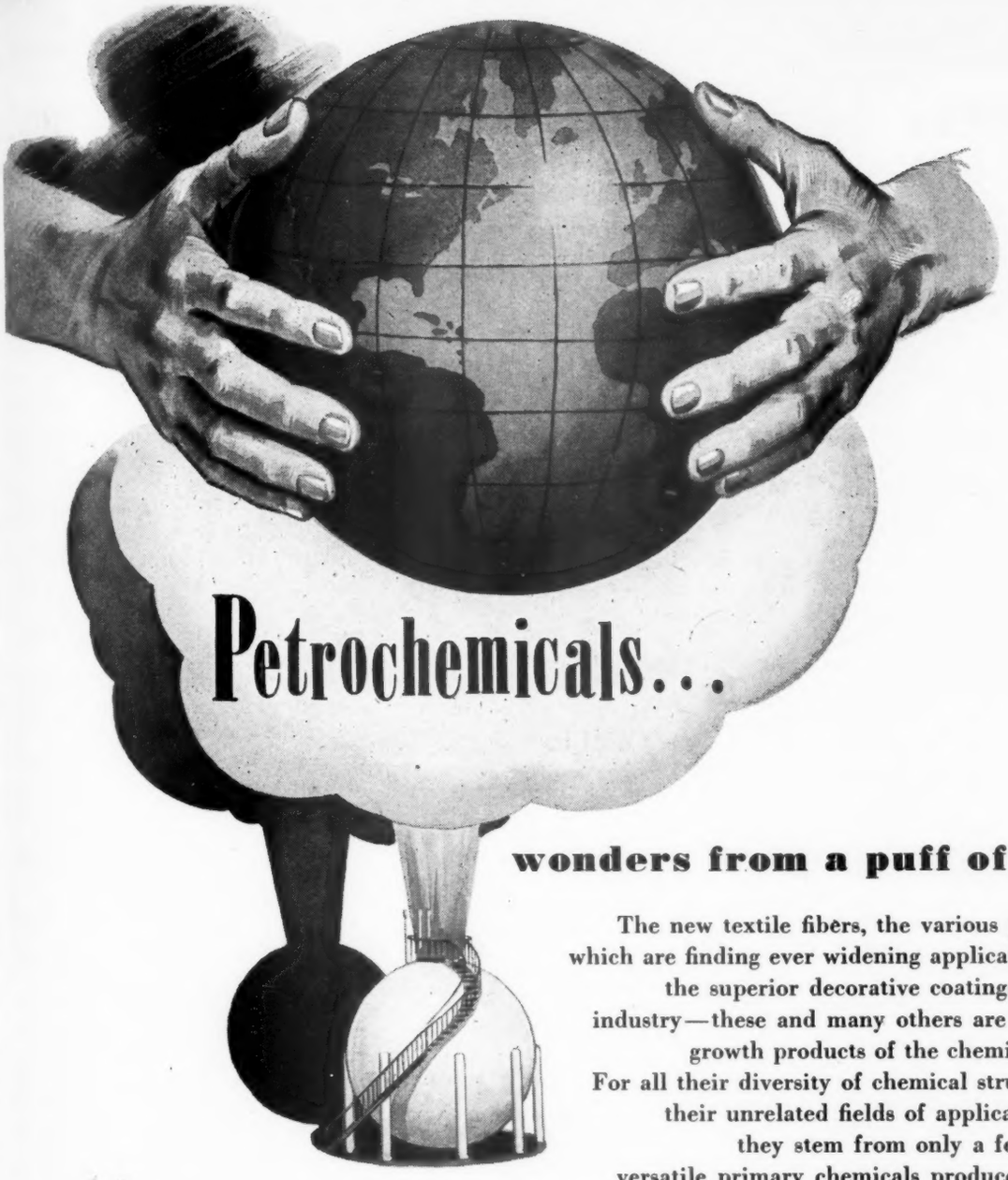

# Petrochemicals...

## wonders from a puff of gas

The new textile fibers, the various plastics which are finding ever widening applications, the superior decorative coatings of the paint industry—these and many others are the growth products of the chemical industry. For all their diversity of chemical structure and their unrelated fields of application, they stem from only a few simple but versatile primary chemicals produced from petroleum gases which we call petrochemicals. At Tuscola, Illinois, National Petro-Chemicals Corporation is now manufacturing such petrochemicals, in particular ethyl alcohol and ethyl chloride. A polyethylene plant will begin operations in 1955. If you need petrochemical building blocks in your production, why not consult with us regarding your raw material requirements.

**NATIONAL PETRO-CHEMICALS**

**CORPORATION**

*A joint enterprise of National Distillers Products Corporation and Panhandle Eastern Pipeline Company*

120 BROADWAY, NEW YORK 5, N. Y.

# New Gasoline Treating Process Removes All Mercaptans

*New type solution containing organic acid takes out mercaptan sulfur by high selective solubility*

C. A. DUVAL* and V. A. KALICHEVSKY*

EXTRACTION of mercaptans from petroleum products is preferable to their conversion to disulfides because of the reduction in sulfur content of the treated distillates. Disulfides left in the oil may be even more harmful to oil quality than the original mercaptans.[2] The importance of complete removal of mercaptans from gasoline as compared to their conversion to disulfides may be visualized from data presented in Table 1.

**TABLE 1. Typical Tel savings for dualayer process over doctor treating.**

| Gasoline | Octane, R-39 + 3cc TEL | | TEL savings*, $/1000 bbl |
|---|---|---|---|
| | Doctor | Dualayer | |
| Absorption | 84.0 | 85.6 | 90 |
| Thermal | 83.2 | 86.0 | 160 |
| Straight-run | 85.9 | 87.2 | 70 |

* TEL at .231 cents per cc.

These data show that in treating gasolines normally encountered at a refinery saving of $160 of TEL per thousand barrels are not unusual because of an increase in the octane number of the leaded gasoline. In many instances considerably greater savings can be obtained depending on the quantity of mercaptans present and the desired octane number of the product.

The Dualayer process secures a doctor sweet product by extracting mercaptans and not converting them to disulfides which remain in the oil.

Mercaptans are acidic and alkalies react with them. Alkalies alone, however, are seldom capable of extracting all mercaptans with the possible exception of the lightest members of the series. Complete removal of mercaptans from petroleum distillates with conventional aqueous alkali hydroxides is attained only in very rare instances.

The addition of organic acids, referred to as solutizers or solventizers,[3] improves the mercaptan extraction efficiency of aqueous alkali hydroxide solutions. Improvement obtained by existing processes, however, is seldom adequate to insure sufficient removal of mercaptans to give products sweet to the doctor test.

Investigation of caustic solutions containing organic acids revealed that at certain concentrations two immiscible layers are formed which are also immiscible with the oil. Commercial processes now in use employ one-phase solutions of composition fairly remote from this critical region in order to avoid such separations. The new process developed at the Magnolia Petroleum Company utilizes the two layers and is referred to as the Dualayer (dual layer) process. The principles on which the process is based are applicable to a large variety of systems involving alkali hydroxides, water and organic substances. For illustration purposes, the system consisting of potassium hydroxide, water and cresylic acid was selected.

Potassium hydroxide has a considerable advantage over sodium hydroxide for extraction of mercaptans. On account of their low viscosity, potassium hydroxide solutions can be used commercially in highly concentrated form. The mercaptan extraction power of these concentrated solutions is high. Losses of potassium hydroxide due to entrainment are less than with sodium hydroxide because of this difference in viscosity. For this reason, in regenerative processes the cost of potassium hydroxide is usually less than that of sodium hydroxide and the extractive power is greater.

Cresylic acid is a mixture of acidic organic substances present in the petroleum distillates from which the mercaptans are removed. Caustic solutions extract these compounds and no outside source is normally required to supply them to the process. In the few

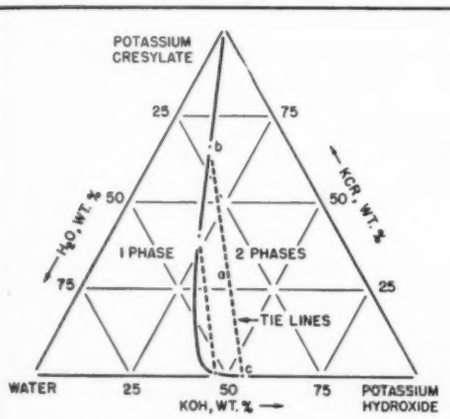


**FIG. 1. Typical three-component composition diagram for potassium hydroxide, potassium cresylate and water.**

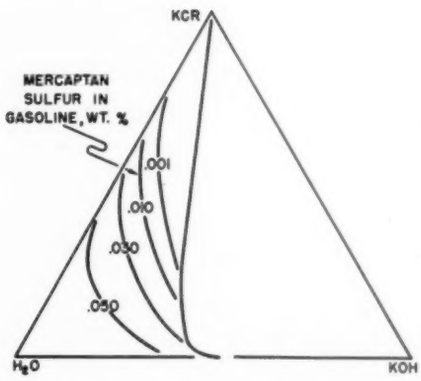


**FIG. 2. Curves showing extraction power of solutions for mercaptan removal.**

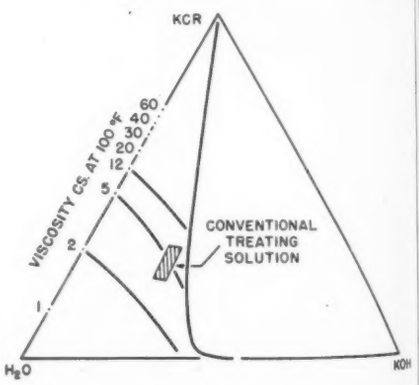


**FIG. 3. Viscosities vs. compositions of three-component extraction solutions.**

instances where distillates are deficient in these acids, they may be obtained from treating other refinery stocks. Composition of cresylic acid from petroleum varies with the nature of the distillate but these variations are minor and do not affect the process efficiency.

Three-component systems are conveniently represented by triangular diagrams. A typical diagram for potassium hydroxide, water and potassium cresylate system is given in Fig. 1. In this instance cresylic acids extracted from catalytically cracked gasolines were employed. Cresylic acids from other sources may slightly affect the position of the boundary line separating the one and two-phase regions. The tie line **a** on the diagram shows the composition of the two layers if the total composition of the mixture corresponds to any composition intersected by the line. The actual compositions of the two layers are represented by points **b** and **c**.

In choosing the most desirable composition of the treating solution for commercial use, several factors must be taken into consideration. The most important of these are the extraction power for mercaptans and viscosity.

Extraction power of solutions for mercaptans may be visualized from concave curves on Fig. 2. They show that the extraction efficiency improves as the curves approach the two-phase region. It also improves with the change in composition of the treating solution as it nears the KCr apex of the triangular diagram given in Fig. 2. In the diagram KCr is used as an abbreviation for potassium cresylate and $H_2O$ and KOH are the conventional chemical symbols for water and the uncombined potassium hydroxide.

Viscosities of the solutions are represented by the convex curves on Fig. 3. Viscosities decrease as the curves approach the $H_2O$ apex on the diagram. Separation of treating solution from the treated distillate is a function of the viscosity of the treating solution. Good separation is obtained with solutions having viscosities below 12 centistokes at 100 F. Solutions of considerably higher viscosity can be used successfully with proper mixing and settling equipment and with continuous filtration of the solution to remove impurities.

Fig. 4 shows that for a given viscosity the highest extraction efficiency is obtained by a solution having a composition on the two-phase boundary line. This is true for viscosities above 5 centistokes at 100 F. Extraction efficiency and viscosity lines in Figs. 2 and 3 are superimposed in Fig. 4.

Equilibrium curves for cresylic acid concentrations in the treating solution and in gasoline are shown in Fig. 5. These curves are important for calculating the amount of cresylic acids introduced with the fresh distillate that will be absorbed by the treating solution or released to the distillate.

The shaded regions on Figs. 4 and 5 represent compositions of conventional treating solutions recommended for use commercially at the present time.

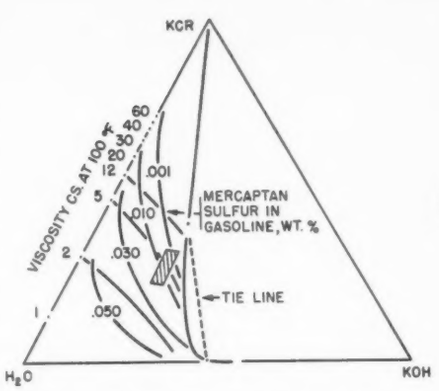


**FIG. 4. For any given viscosity, highest extraction efficiency is obtained from a solution having a composition on the two-phase boundary line.**

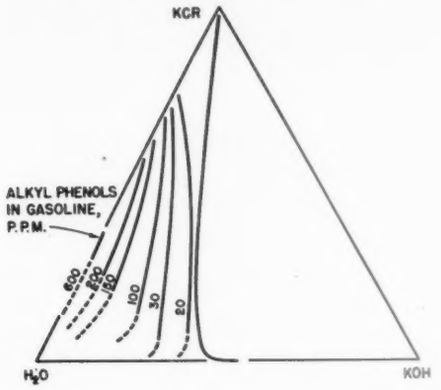


**FIG. 5. Equilibrium curves for cresylic acid concentrations in treating solutions and in gasoline.**

It may be seen that the ultimate ability of these solutions for extracting mercaptans has not been utilized. This is also demonstrated by the data presented in Table 2 on mercaptan extraction by the Dualayer and conventional solutizer solutions from a West Texas straight-run gasoline.

Data are presented on percentage basis for better visualization. The 100 per cent removal of mercaptans corresponds to a product sweet to the doctor test and containing less than 0.0005 weight per cent mercaptan sulfur.

The tabulated data show the ease with which the mercaptans are removed from the oil by the Dualayer process. With the conventional treating solutions, the doctor sweet products could not be obtained even by raising the solution to distillate ratio more than 20 times above that employed in the new process.

The exceptional performance of the Dualayer process is due to the fact that the potassium hydroxide, potassium cresylate and water content of the treating solution are completely under control. Treating solution composition on conventional solutizer units is normally out of control and reaches an unfavorable equilibrium for mercaptan extraction. The water content or boiling point of the solution is usually the only method used to adjust composition and the potassium hydroxide to potassium cresylate ratio varies until it reaches

**TABLE 2. Mercaptan removal by dualayer and solutizer solutions from West Texas gasoline.**

| Treating solution | Solution to-gasoline ratio, vol. | Mercaptan removal, % One stage | Two stages | Three or more stages |
|---|---|---|---|---|
| Dualayer.... | 0.02 | 91 | 100 | 100 |
| Solutizer.... | 0.20 | 71 | 80 | 93 |
| | 0.40 | 84 | 93 | 96 |

NOTE: Initial mercaptan sulfur = 0.110 wt %.

**The Authors**

V. A. Kalichevsky C. A. Duval, Jr.

V. A. Kalichevsky is consulting chemical engineer for Magnolia Petroleum Company, in Beaumont, Texas. A native of Russia, Kalichevsky came to this country and entered California Institute of Technology, graduating in 1924. He then went into refining research, development, and plant work with Union Oil of California, and in 1929 joined Standard Development in similar work, transferring to Socony-Vacuum two years later. In time he became general supervisor of Socony's research and development department, and in 1944 accepted his present position with Magnolia, Socony affiliate.

C. A. Duval, Jr., is supervisory process engineer, process control laboratory of Magnolia Petroleum Company in Beaumont. He was graduated from University of Texas, and joined Magnolia in 1941, as chemist in the analytical laboratory. He received various promotions until receiving his present appointment in 1949.

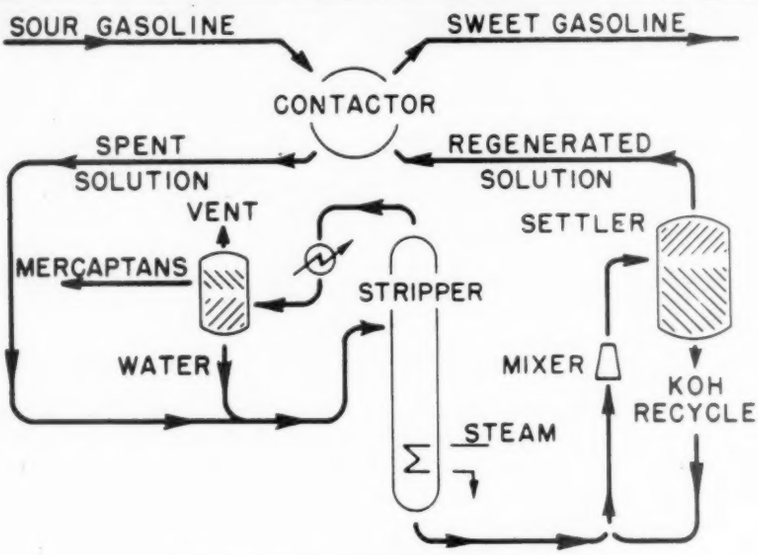


**FIG. 6. Flow diagram of Dualayer process.**

equilibrium with the organic acids in the oil. The resulting solution is deficient in potassium hydroxide and is relatively ineffective for the extraction of mercaptans. High treating ratios and large strippers are required with this type of solution for even partially satisfactory results.

In the Dualayer process the water content and the potassium hydroxide content are both controlled. The water content is controlled by the stripper temperature and the potassium hydroxide content by the equilibruim with the potassium hydroxide-water layer in the equilibrium drum. As the solution consists of only three major components, control of two of them automatically controls the third. In other words, the Dualayer solution has only one degree of freedom and the stripper temperature controls its composition. Conventional solutions, with only one homogeneous phase, have two degrees of freedom and cannot be controlled satisfactorily by the stripper temperature alone.

Regeneration of the Dualayer solution is easy. Less than 10 lb of steam per barrel of gasoline charge was needed in the pilot unit to remove mercaptans from the treating solution used in the experiments reported in Table 2. Several modifications of the regeneration procedure are possible. The coexistence of three layers—gasoline, potassium hydroxide and potassium cresylate—in equilibrium with respect to mercaptan concentrations shows that either of the two alkali layers will reduce the mercaptan content of the gasoline. The favorable equilibrium conditions, however, are established on account of the tremendous absorptive capacity of the potassium cresylate layer for potassium mercaptides. In the absence of the potassium cresylate layer, mercaptans distribute relatively evenly between the gasoline and potassium hydroxide solution and their extraction becomes difficult. If the spent potassium hydroxide solution from treating is brought in contact with the potassium cresylate layer, mercaptans are absorbed by this layer and the potassium hydroxide solution regenerated.

Regeneration of mercaptans from the potassium cresylate layer is accomplished by diluting with water and steam stripping the diluted solution. Since the required potassium cresylate to gasoline treating solution dosage is very low, in some cases it may be as low as 2 volume per cent, only a small quantity of water is required to provide very dilute solutions for stripping. The advantages of stripping dilute solutions may be visualized from Fig. 2. The ease of stripping is inversely proportional to the mercaptan extraction ability of the solution and water dilution reduces the mercaptan extraction power of the solution.

A typical flow diagram for a commercial process is shown in Fig. 6. It is only one of the possible variations of the flow of materials which was found to be the best for solving a particular refinery problem. Gasoline distillate containing mercaptans enters two-stage countercurrent extraction system **A.** The small quantity of the treating solution employed favors the use of mixing and settling stages in preference to tower extraction. The doctor sweet gasoline is pumped to storage and the spent treating solution is diluted with an equal volume of water and settled in equipment now shown to remove small quantities of entrained gasoline. The diluted solution is directed to the regeneration tower **B** equipped with closed steam coils. Water, added to the treating solution in the previous step, is converted into stripping steam by the closed steam coils. It is removed as a liquid on the water separation tray in the upper portion of the column and used for diluting the stream of the spent solution.

Vapors from the stripper are condensed and the mercaptans are withdrawn from the system from **C.** The water layer is returned to the top of the stripper tower. The lean treating solution is blended with a small quantity of 50 deg Be′ potassium hydroxide solution and fed to the Dualayer equilibrium drum **D.** The two layers are separated, and the top layer, which contains the potassium cresylates, is used as the treating solution. Small quantities of potassium cresylate solution may be withdrawn from the system if excessive quantities of cresylic acid are present in the raw gasoline distillate. The unit described above is now under construction at the Beaumont refinery of the Magnolia Petroleum Company.

The use of the Dualayer process is not limited to gasoline but it can be applied successfully to the refining of considerably heavier petroleum distillates, such as kerosine, and distillate fuel oils, which are not treated satisfactorily with conventional mercaptan extraction processes. Application of the Dualayer principle to improving the long term storage properties[1] of catalytic distillate fuel oils will be described in another paper in the near future.

## New Process Announced

Universal Oil Products Company and Union Oil Company of California announced that the Unifining process for the purification of petroleum distillates is now available to the petroleum refining industry. A refiner may secure the benefit of the combined techniques and patent rights through a single license from either party.

The process is particularly advantageous for pretreating certain feed stocks before they are processed in a cat reforming unit, whose excess hydrogen makes an economical source of hydrogen for the Unifining unit.

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# NGAA Men Solve Practical Problems at Odessa . . . . . .

Between 500 and 600 technical and operating men of the natural gasoline industry heard leaders in their field discuss methods and solutions to problems with which they are faced every day at the one-day Permian Basin regional meeting, February 26, 1954. These problems ranged all the way from operating-and-maintenance plant difficulties to the highly technical and economic problems faced by any company that may be considering the possibilities of venturing into the manufacture of petrochemicals.

Conservation of the tremendous quantities of natural gas that is either flared, sold for a useful purpose, or must be held in the ground, by finding a market for it, then transporting it to the consumer, is the principle and theme on which El Paso Natural Gas Company operates, its president Paul Kayser told the gasoline men. The tremendous reserves of western Texas, the Trans-Pecos country, New Mexico, and adjacent areas would have laid dormant and undeveloped if suitable markets had not been developed and the gas piped to those markets, largely West Coast consumption.

Paul Kayser

**Paul Kayser, president, El Paso Natural Gas, explained meaning of gas conservation and how it is accomplished.**

T. R. Goebel

**T. R. (Ted) Goebel, vice president, Columbian Carbon, presided over afternoon session.**

H. A. Legatski

**H. A. Legatski, Phillips, showed fundamental needs for petrochemical industry.**

E. W. Wallace

**E. W. Wallace, Shell, outlined corrosion problems and how to fight them.**

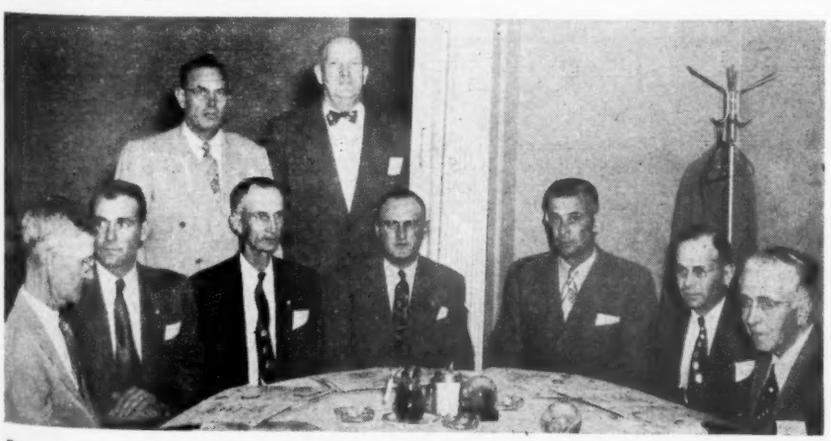
H. Y. Beck

**H. Y. Beck, chief engineer, American Meter, presented paper by W. R. Kehoe on orifice meter measurement.**

H. P. McClintock

**H. P. McClintock, Tex-Harvey Gasoline, presided over morning session.**

**Engine and Compressor Maintenance Panel and moderator, Vern Ford, Clark Bros.; A. R. Worster, Ingersoll-Rand; C. J. Kremer, Jr., C. Lee Cook Manufacturing; and W. H. Phillips, Phillips Petroleum Company, moderator.**



**Group of Skelly Oil men and friends at luncheon. Standing: J. R. Green, superintendent, New Mexico district, Skelly; Homer L. Ramsey, Nickles Machine. Sitting, R. R. Johnston, gas tester; R. E. Farley, chief operator; C. C. Coffey, superintendent, No. 2 plant, Eunice; I. J. Frields, gas tester; W. A. Pershall, chief engineer, No. 1 plant; C. W. Mullins, superintendent No. 1 plant south of Eunice, and A. H. Bazell, gas tester.**

The manufacture of petrochemicals and the establishment of such factories requires certain natural advantages and available facilities, said H. A. Legatski, petrochemicals analyst for Phillips Petroleum Company. These factors include water in adequate amounts, supply of raw materials, transportation facilities, and commercial consuming outlets within economic distances of the plants, Legatski said. Given the absence of any of these primary factors and a petrochemical venture starts with a handicap, success is uncertain.

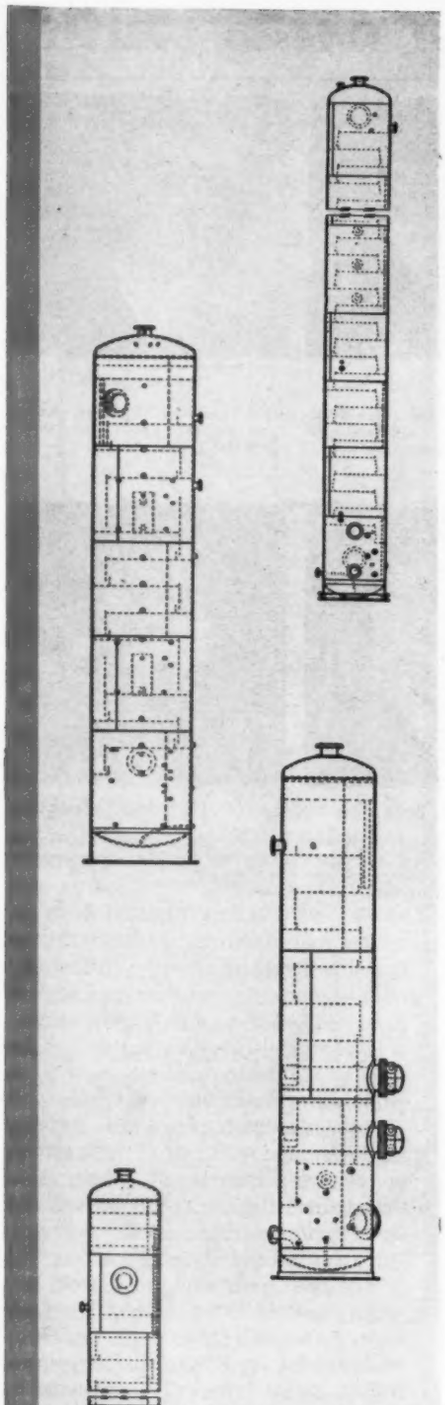
An outstanding panel on maintenance of engines and compressors included three papers on valves, pistons, and pressure balance were given by Vern Ford, Clark Bros., A. R. Worster, Ingersoll-Rand, and C. J. Kremer, Jr., of C. Lee Cook Manufacturing Company. And these authors remained after presenting their papers as a quiz panel to answer a number of practical questions.

After hearing a careful, factual "History and Future of the Permian Basin," by V. E. Cottingham, in which many pertinent facts, unknown to those outside the immediate area were discussed. A banquet was served in the evening by the Supply Men's Association.

National meetings of technical associations have become so huge in attendance numbers that regional meetings have become a necessity.



XUM



TULSA TYPE
NATURAL GASOLINE PLANTS
Flint can fabricate the major units for a natural gasoline plant such as pressure vessels, bubble towers, heat exchangers and preheaters, deethanizers, depropanizers and debutanizer columns.
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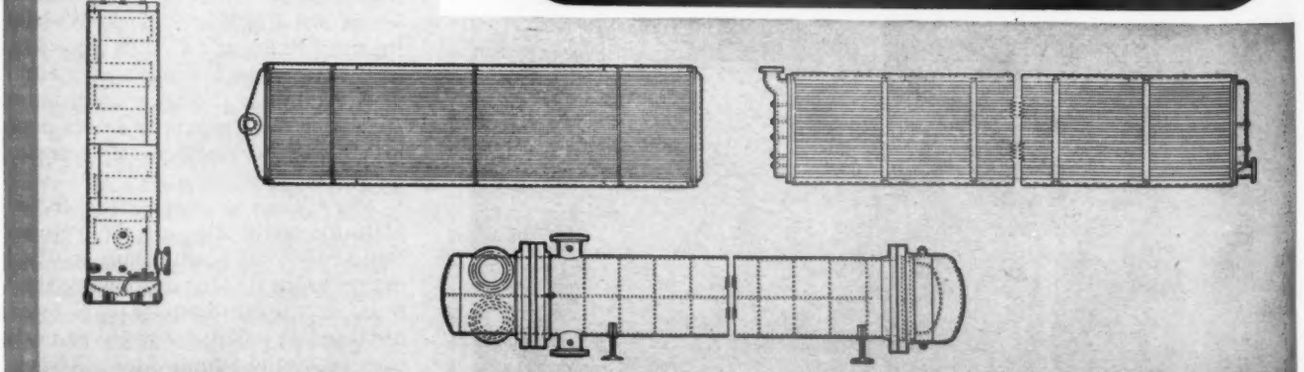

PLATE FABRICATING STRUCTURAL FABRICATING
REINFORCING FABRICATING WAREHOUSE PRODUCTS

# Cat Polyforming of Shale Oil Better Than Catalytic Cracking†

*Seven per cent higher gasoline yield by catalytic polyforming shale "gas oil"; 'Poly' gasoline has excellent color stability*

**LLOYD BERG*, L. G. MAYFIELD*, H. A. SANER* and R. L. CRECELIUS****

THERMAL polyforming and catalytic cracking processes have been combined into one operation where a petroleum gas oil is catalytically cracked in the presence of added hydrocarbon gases.[2] This process has been called catalytic polyforming. The process was reported to give improved yields and higher octane ratings of the gasoline product.

Oil shale is a stratified rock formed from mud and organic matter laid down on the floor of ancient seas and lakes. Later upheavals of the ocean bottoms followed by wind and water erosion have laid bare these tremendous seams of oil shale. The largest deposit, known as the Green River formation, is in Colorado, Utah, and Wyoming. Estimates of the oil that could be produced from the Rifle-DeBeque area of western Colorado alone are in the range of 200-300 billion barrels, which is more than 10 times as much oil as all the petroleum produced in the

†Presented before A. I. Ch. E., San Francisco, 1953.

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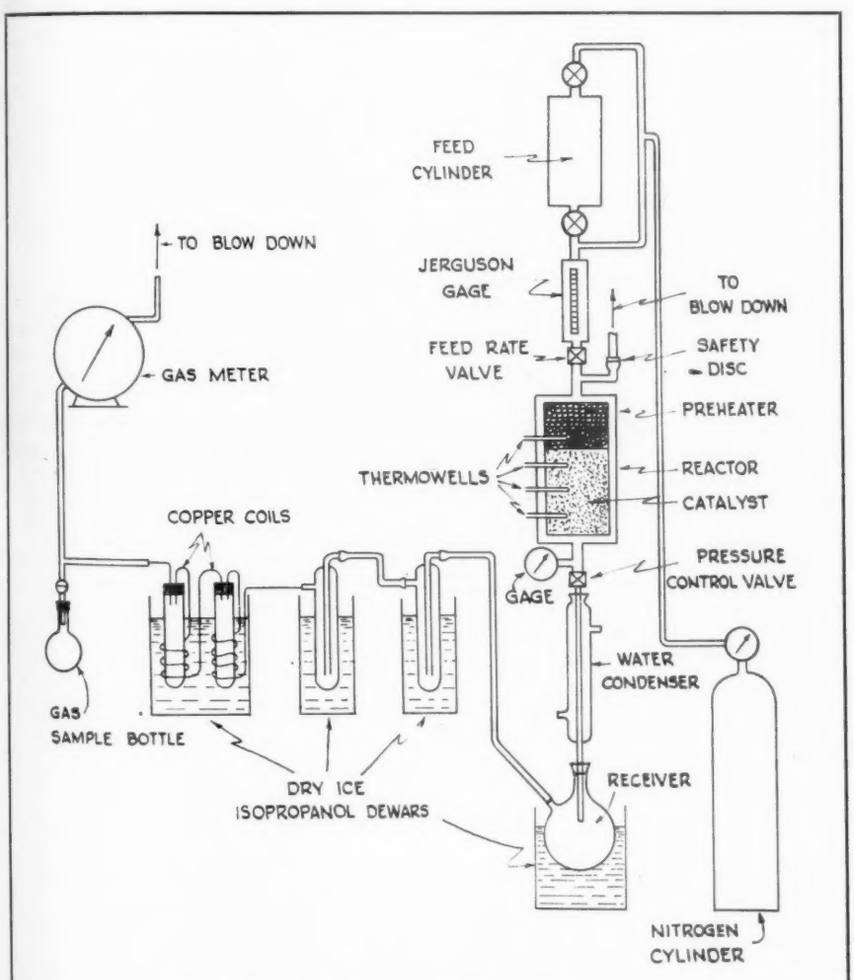



**FIG. 1. Diagram of catalytic polyforming equipment.**

**Catalytic polyforming was applied to shale oil using isobutylene and n-butane as the added gas in an attempt to produce a more stable gasoline in higher yields from this source.**

**Houdry aluminum silicate catalyst in a fixed bed system was employed in all runs. The investigation was conducted at temperatures from 360 C to 573 C (680 to 1063+ F) and liquid space velocities from 0.5 to 6.0. During an average run approximately 450 grams of feed (oil and gas) were passed over 1000 ml of catalyst using a pressure of 900 lb per square inch gage.**

**Isobutylene, but not n-butane, when used as the outside gas gave higher yields of gasoline at both high and low space velocities than could be obtained by conventional catalytic cracking of shale oil. Catalytic polyforming gave maximum gasoline yields at higher space velocities and lower temperatures than catalytic cracking. The gum content was essentially the same regardless of how the gasoline was prepared. The color instability of the shale oil gasoline was almost completely eliminated when prepared by catalytic polyforming.**

United States since the opening of the Drake well in 1859.

The organic matter in oil shale is present in the form of a high molecular weight solid organic complex known as kerogen. This material has to be cracked to produce a liquid oil of lower molecular weight known generally as shale oil. As shale oil is already a cracked product, the production of gasoline by further thermal cracking of the oil did not seem to be necessarily the best way and an application of the catalytic polyforming process to shale oil was attempted. Cracking of shale oil gives a gasoline having a foul smell, a high percentage of sulfur and nitrogen compounds, a high gum forming potential and a poor color stability. It was hoped that the product from the catalytic polyforming of shale oil would have somewhat improved characteristics.

### Equipment

The equipment used in this investigation is shown in Fig. 1 and was composed of four major sections: Feeding section, reactor section, condensing and receiving section, and the safety equipment.

The feeding section included a nitrogen cylinder, a feed cylinder made of 3-in. extra strong steel pipe with 3000 psig rated valves at each end, and a visible liquid level gage. At the lower end of the gage was attached a 6000 lb valve for adjustment of the rate of feed. From a side arm below the feed rate valve was attached a frangible disk safety valve. The reactor located below the feed rate valve was made from a 15 in. section of 3-in. extra strong steel pipe. One thousand milliliters of catalyst was placed in the lower 11 in. of the reactor body and the remaining 4 in. were filled with assorted sizes of steel balls, the largest of which was 9/16-in. diameter, which served as the preheat section. A 0-2000 psig pressure gage and a 6000 lb ½-in. valve was connected below the reactor. This valve, operated manually, was employed to regulate the pressure in the reactor. Thermocouples were inserted in one-eighth inch steel pipe welded at approximately three inch intervals along the length of the reactor and served to indicate preheat and catalyst bed temperatures. Heating was accomplished and controlled by one 220-v and two 110-v Nichrome windings wrapped around the reactor.

The reactor effluent, after pressure reduction, was led through a glass Liebig condenser and the liquid product collected in the flask subsequently used in the distillation. Vapors not condensed in this flask passed through a series of four glass traps immersed in dry ice-isopropanol baths, through two copper coil condensers also immersed in dry ice-isopropanol and thence through a wet test gas meter and the blowdown line. A branch of this line was connected to an evacuated 200 ml round bottom, stopcock equipped flask used to take a gas sample for density determination.

Gasoline rectifications were carried out in a Claisen flask fitted with a water-cooled condensing finger. Flue gas from carbon burn-offs was analyzed for $CO_2$, $O_2$, and CO in a standard Orsat apparatus. Analyses of gases from the feed cylinder after the run and of non-condensable gases issuing from the reactor during the run were made with a low-temperature (liquid nitrogen) gas fractionation apparatus. This unit was also used to make analyses on outside gases used in conjunction with the gas oil charge.

### Materials

The shale oil was a diesel oil fraction from the shale oil crude produced in the retorting operation carried out by the Bureau of Mines Demonstration plant at Rifle, Colorado. Laboratory inspection data for this shale oil are given in Table 1. The sample has been given Bureau of Mines identification number RRS-48-442.

The iso-butylene and n-butane used as outside gases were commercial grade obtained from Phillips Petroleum Company.

### Gum Determinations and Removal

In order to establish the gum content of the shale oil gasoline, 25 ml of the gasoline to be tested was evaporated to dryness in a previously weighed evaporating dish on a heated sand bath. The temperature of the sand was gradually raised from 150 C to 210 C during the evaporation. The evaporating dish was allowed to stand in a desiccator for four hours and then weighed to the closest one-half milligram. The difference in weight of the evaporating dish was multiplied by four to give the milligrams of gum per 100 ml of gasoline.

The shale oil gasoline samples were given a standard chemical treatment in preparation for the octane number determinations. This treatment consisted of shaking the gasoline sample with 10 per cent by volume of a 10 per cent sodium hydroxide solution for two minutes in a separatory funnel and separating, two minutes with 10 per cent by volume of 10 per cent sulfuric acid, two minutes with 10 per cent by volume of water, and finally six minutes with 2.3 ml of 98 per cent sulfuric acid per 100 ml of gasoline. No determination was made of gum content after the standard treatment. Samples on which octane number determinations were made were redistilled after the chemical treatment.

### Results

Table 2 presents the results of cracking shale oil with a Houdry synthetic aluminum silicate catalyst. Six runs

**TABLE 1. Shale oil inspection data.**

ASTM distillation of diesel fuel cut RRS-48-442 from Crude N-T-U Shale oil RRS-48-395

| Temperatures in deg F corrected to 760 mm | |
|---|---|
| IBP | 498 |
| 5% | 524 |
| 10% | 532 |
| 20% | 540 |
| 30% | 547 |
| 40% | 552 |
| 50% | 558 |
| 60% | 565 |
| 70% | 575 |
| 80% | 586 |
| 90% | 602 |
| 95% | 617 |
| E.P. | 643 |
| Recovery | 99.0% |
| Residue | 0.9% |
| Loss | 0.1% |
| Specific gravity at 60 F | 0.8855 |
| Molecular weight (calc'd.) | 210 |

**TABLE 2. Catalytic cracking of shale oil.**

| Run number | 1 | 2 | 3 | 4 | 5 | 6 |
|---|---|---|---|---|---|---|
| Number of previous runs on catalyst | 2 | 51 | 53 | 54 | 55 | 56 |
| Average reactor temperature, deg C | 502 | 401 | 466 | 517 | 549 | 573 |
| Average operating pressure, psig | | Atmospheric | | | | |
| Liquid space velocity, hr.$^{-1}$ | 0.67 | 0.71 | 0.70 | 0.70 | 0.66 | 0.67 |
| Mol Ratio | — | — | — | — | — | — |
| Material charged | | | | | | |
| Outside gas, type | — | — | — | — | — | — |
| Outside gas, gms. | — | — | — | — | — | — |
| Charge stock, gms. | 309 | 269 | 295 | 303 | 298 | 311 |
| Total charge, gms. | 309 | 269 | 295 | 303 | 298 | 311 |
| Recovered Material | | | | | | |
| Hydrocarbon liquid product, gms. | 217.7 | 218.4 | 252.2 | 221.4 | 179.9 | 144.1 |
| Condensable gases, gms. | 13.0 | 1.3 | 5.9 | 20.7 | 31.8 | 51.1 |
| Permanent gases, gms. | 21.0 | 3.2 | 12.0 | 25.6 | 46.5 | 63.0 |
| Oil from catalyst, gms. | 0 | 19.4 | 7.2 | 6.2 | 2.3 | 4.5 |
| Carbon by burn-off, gms. | 25.0 | 17.0 | 16.0 | 24.4 | 30.2 | 44.1 |
| Total recovered, gms. | 276.7 | 259.3 | 293.3 | 298.3 | 290.7 | 306.8 |
| Losses by difference, gms. | 32.3 | 9.7 | 1.7 | 4.7 | 7.3 | 4.2 |
| Per cent losses on charge | 10.4 | 3.6 | 0.6 | 1.6 | 2.5 | 1.4 |
| Distillation Data | | | | | | |
| Gasoline, 52-410 F., gms. | 73.0 | 34.1 | 45.8 | 70.3 | 74.8 | 84.5 |
| Residue, gms. | 141.0 | 196.7 | 205.0 | 153.8 | 109.9 | 82.3 |
| Weight per cent gasoline, 52-410 F. | 23.6 | 12.7 | 15.5 | 23.2 | 25.1 | 27.1 |
| Weight per cent conversion of oil charged | 54.4 | 27.0 | 30.5 | 49.4 | 63.2 | 73.5 |
| Weight per cent ultimate yield, gasoline | 43.4 | 46.9 | 50.8 | 47.0 | 39.7 | 36.9 |
| Weight per cent carbon laydown | 8.1 | 6.3 | 5.4 | 8.1 | 10.1 | 14.2 |
| Volume per cent gasoline | 26.9 | 14.5 | 17.7 | 26.4 | 29.8 | 30.9 |
| Volume per cent conversion of oil charged | 62.0 | 30.8 | 34.8 | 56.3 | 72.0 | 83.7 |
| Volume per cent ultimate yield | 49.4 | 53.7 | 58.0 | 53.5 | 47.2 | 42.0 |

**TABLE 3. Catalytic polyforming of shale oil.**

| Run Number | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| No. of Previous Runs on Catalyst | 45 | 48 | 49 | 50 | 43 | 44 | 46 | 47 | 56 | 57 | 58 | 59 | 60 | 61 | 62 | 63 | 64 | 65 | 66 |
| Average reactor temp., deg C | 364 | 443 | 388 | 479 | 365 | 424 | 464 | 501 | 385 | 460 | 433 | 509 | 481 | 392 | 427 | 486 | 487 | 480 | 511 |
| Average operating pressure, psig | 900 | 900 | 900 | 900 | 900 | 900 | 900 | 900 | 900 | 900 | 900 | 900 | 900 | 900 | 900 | 900 | 900 | 900 | 900 |
| Liquid space velocity, hr$^{-1}$ | 0.60 | 0.65 | 0.68 | 0.60 | 4.9 | 5.0 | 4.0 | 5.0 | 0.6 | 0.68 | 0.65 | 0.63 | 0.54 | 4.4 | 4.2 | 4.8 | 5.0 | 5.0 | 5.2 |
| Mol ratio | 2.46 | 2.58 | 2.44 | 2.55 | 2.03 | 2.36 | 2.75 | 2.68 | 2.22 | 2.42 | 2.35 | 2.32 | 2.42 | 2.18 | 2.64 | 2.18 | 2.57 | 2.41 | 2.29 |
| Material Charged | | | | | | | | | | | | | | | | | | | |
| Outside gas, type | Isobutylene | | | | | | | | n-Butane | | | | | | | | | | |
| Outside gas, gms | 185 | 190 | 176 | 181 | 152 | 176 | 201 | 189 | 168 | 183 | 184 | 174 | 178 | 164 | 197 | 162 | 192 | 179 | 168 |
| Charge stock, gms | 281 | 278 | 270 | 266 | 282 | 279 | 275 | 265 | 276 | 272 | 284 | 271 | 266 | 274 | 270 | 269 | 271 | 269 | 266 |
| Total charge, gms | 466 | 468 | 446 | 447 | 434 | 455 | 476 | 454 | 444 | 454 | 468 | 445 | 444 | 438 | 467 | 431 | 463 | 448 | 434 |
| Recovered Material | | | | | | | | | | | | | | | | | | | |
| Hydrocarbon liquid product, gms | 326.0 | 258.2 | 297.1 | 183.3 | 275.7 | 254.0 | 226.5 | 128.4 | 317.2 | 313.3 | 336.1 | 185.1 | 250.5 | 277.9 | 318.9 | 207.8 | 228.2 | 221.4 | 169.0 |
| Condensable gases, gms | 73.5 | 89.1 | 76.6 | 108.2 | 98.6 | 135.4 | 151.5 | 141.3 | 72.7 | 69.7 | 73.4 | 105.3 | 90.9 | 117.3 | 108.0 | 167.7 | 167.5 | 164.0 | 160.2 |
| Permanent gases, gms | 11.5 | 30.6 | 13.0 | 56.0 | 9.8 | 18.7 | 41.0 | 85.0 | 10.0 | 28.8 | 16.0 | 80.0 | 58.5 | 7.5 | 12.7 | 23.0 | 31.9 | 35.2 | 71.6 |
| Oil from catalyst, gms | 26.9 | 6.2 | 19.7 | 4.7 | 18.6 | 8.2 | 4.5 | 4.2 | 19.7 | 6.5 | 11.0 | 3.2 | 5.0 | 17.6 | 9.3 | 6.1 | 4.8 | 5.6 | 2.3 |
| Carbon by burn-off, gms | 21.6 | 54.3 | 30.7 | 76.5 | 17.9 | 29.8 | 49.0 | 64.0 | 18.8 | 30.0 | 24.4 | 59.5 | 47.2 | 16.9 | 15.5 | 15.5 | 30.2 | 25.8 | 34.0 |
| Total recovered, gms | 459.5 | 438.4 | 437.1 | 428.7 | 420.6 | 446.1 | 472.5 | 422.9 | 438.4 | 448.3 | 460.9 | 433.1 | 452.1 | 437.2 | 464.4 | 420.1 | 462.6 | 452.0 | 437.1 |
| Losses by difference, gms | 6.5 | 29.6 | 8.9 | 18.3 | 13.4 | 8.9 | 3.5 | 31.1 | 5.6 | 5.7 | 7.1 | 11.9 | 8.1 | 0.8 | 2.6 | 10.9 | 0.4 | 4.0 | 3.1 |
| Per cent losses on charge | 1.4 | 6.3 | 2.0 | 4.1 | 3.0 | 2.0 | 0.7 | 6.8 | 1.3 | 1.3 | 1.5 | 2.7 | 1.8 | 0.2 | 0.6 | 2.5 | 0.1 | 0.9 | 0.7 |
| Distillation Data | | | | | | | | | | | | | | | | | | | |
| Gasoline, 52-410 deg F, gms | 69.3 | 94.7 | 75.6 | 89.0 | 47.6 | 83.5 | 94.9 | 89.1 | 22.4 | 62.0 | 57.7 | 64.9 | 65.1 | 19.4 | 27.9 | 41.6 | 52.2 | 40.6 | 47.9 |
| Residue, gms | 224.5 | 112.8 | 190.8 | 64.9 | 211.1 | 158.6 | 97.9 | 77.3 | 215.9 | 127.7 | 173.7 | 51.8 | 96.1 | 214.0 | 198.5 | 158.8 | 136.4 | 155.8 | 110.3 |
| Weight % gasoline, 52-410 deg F | 24.0 | 34.0 | 28.0 | 33.4 | 16.9 | 29.9 | 34.0 | 33.6 | 8.1 | 22.8 | 20.4 | 23.9 | 24.4 | 7.1 | 10.4 | 15.5 | 19.2 | 15.1 | 18.0 |
| Weight % conversion of oil charged | 20.1 | 59.5 | 29.4 | 75.6 | 25.1 | 43.3 | 56.4 | 70.8 | 21.8 | 53.3 | 39.0 | 80.8 | 63.9 | 22.0 | 26.2 | 41.0 | 49.7 | 42.1 | 58.5 |
| Weight % ultimate yield | 119.5 | 57.1 | 95.1 | 44.1 | 67.3 | 69.0 | 60.3 | 47.5 | 37.5 | 42.6 | 52.4 | 29.6 | 38.1 | 31.8 | 39.7 | 37.8 | 38.6 | 35.9 | 30.8 |
| Weight % carbon laydown | 4.6 | 11.6 | 6.9 | 17.1 | 4.1 | 6.6 | 10.3 | 14.1 | 4.2 | 6.6 | 5.2 | 13.4 | 10.6 | 3.9 | 3.3 | 3.6 | 6.5 | 5.8 | 7.8 |
| Volume % gasoline | 27.4 | 38.8 | 31.9 | 38.1 | 19.3 | 34.1 | 38.8 | 38.3 | 9.2 | 26.0 | 23.2 | 27.2 | 27.8 | 8.1 | 11.9 | 17.7 | 21.9 | 17.2 | 20.5 |
| Volume % conversion of oil charged | 22.9 | 67.8 | 33.5 | 86.2 | 28.6 | 49.4 | 64.2 | 80.7 | 24.8 | 60.8 | 44.5 | 92.0 | 72.9 | 25.1 | 29.8 | 46.7 | 56.6 | 48.0 | 66.7 |
| Volume % ultimate yield | 136. | 65.2 | 108. | 50.3 | 76.9 | 78.8 | 68.8 | 54.2 | 42.2 | 48.7 | 59.5 | 33.7 | 43.5 | 36.8 | 45.4 | 43.2 | 44.1 | 41.0 | 35.0 |

were made at temperatures varying from 401 C to 573 C (754-1063 F); space velocity was held between 0.66 and 0.71 volumes of feed per volume of catalyst per hour.

The highest yield of gasoline obtained from the catalytic cracking of shale oil was 27.1 weight per cent or 30.9 volume per cent at 573 C. It will be noted that gasoline yield does not go through a maximum as might be expected, as it is not possible with the Houdry catalyst [sintering point 600 C (1112 F)] to go to a high enough temperature to obtain the higher conversions where the gasoline yield would fall off. The maximum single-pass yield of gasoline from catalytic cracking of shale oil must occur at 570 C (1058 F) or higher while Berg, et al[2] found that maximum single-pass yield for a Phillips Petroleum Company topped virgin gas oil cracked under the same conditions occurred at a temperature between 380 and 400 C (716-752 F). From this it is apparent that the structure of the shale oil molecule must be such that it requires a much higher average energy of activation for cracking than does a petroleum gas oil.

The theoretical figure, ultimate yield on oil charge, is determined by assuming that all material boiling at a temperature higher than that of the gasoline fraction is unchanged shale oil and if it were recycled the same conversion could be effected again. Actually this is not true since each successive recycle makes the oil more refractory.

The gasoline produced from the high temperature catalytic cracking of shale oil had a more offensive odor than the low temperature cracked gasoline, but at the same time, was characterized by a much better color stability.

Runs 7 to 14 inclusive of Table 3 present the results of catalytic polyforming of shale oil at a pressure of 900 psig using iso-butylene as the outside gas. Four runs were made at temperatures varying from 364 C to 479 C (687-894 F), using a space velocity of 0.6 to 0.68 hr.$^{-1}$, and four runs at temperatures varying from 365 C to 501 C (689-934 F), using a space velocity of 4.0 to 5.0 hr.$^{-1}$

A maximum yield of 34 weight per cent and 38.8 volume per cent gasoline was obtained at a temperature of 443 C (830 F) in the low space velocity series of runs. This is 6.9 per cent more gasoline on oil charge than the maximum obtained from a straight catalytic crack. The maximum yield was obtained at a temperature 130 C (234 F) lower than that required in catalytic cracking.

It can be readily seen that catalytic polyforming using iso-butylene as the outside gas gives an increased ultimate yield. This can be accounted for by polyforming of the shale oil, polymerization of iso-butylene to hydrocarbons in the gasoline boiling range and polymerization to material with a boiling point greater than that of the gasoline fraction. The latter would, in effect, make it appear that there were a larger percentage of the unchanged shale oil remaining and therefore increase the calculated ultimate yield.

**TABLE 4. Results of gum tests on shale oil gasoline.**

| Run number | Outside gas | Av. temp. deg C | % Conversion | Space velocity hr$^{-1}$ | mg. Gum per 100 cc |
|---|---|---|---|---|---|
| 3 | None | 466 | 30.5 | .70 | 744 |
| 5 | None | 549 | 63.2 | .66 | 120 |
| 6 | None | 573 | 73.5 | .67 | 136 |
| 7, 9 | i-$C_4H_8$ | 376 | 56.5 | .64 | 930 |
| 8 | i-$C_4H_8$ | 443 | 59.5 | .65 | 190 |
| 10 | i-$C_4H_8$ | 479 | 75.6 | .60 | 216 |
| 13 | i-$C_4H_8$ | 464 | 56.4 | 4.0 | 917 |
| 14 | i-$C_4H_8$ | 501 | 70.8 | 5.0 | 361 |
| 16 | n-$C_4H_{10}$ | 460 | 53.3 | .68 | 158 |
| 19 | n-$C_4H_{10}$ | 481 | 63.9 | .54 | 380 |
| 20 | n-$C_4H_{10}$ | 392 | 22.0 | 4.4 | 2320 |
| 22 | n-$C_4H_{10}$ | 486 | 41.0 | 4.8 | 507 |
| 25 | n-$C_4H_{10}$ | 511 | 58.5 | 5.2 | 319 |

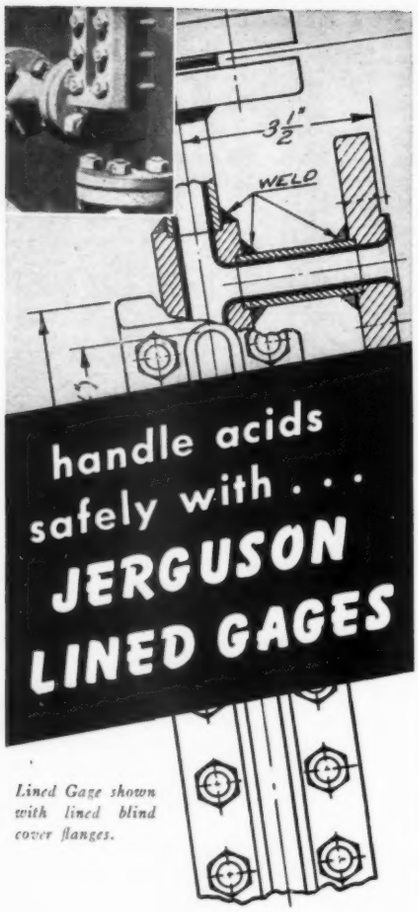
* Charge stock, shale oil plus indicated outside gas.

A maximum yield of 34 weight per cent or 38.8 volume per cent gasoline on oil charge was obtained at a temperature of 464 C (867 F) and a space velocity of 4-5. It is quite remarkable that exactly the same yield was obtained as from the low (0.6-0.68 hr$^{-1}$) space velocity runs with a slightly smaller conversion, a temperature only 21 C (38 F) higher, and a space velocity more than six times as great. The design of the equipment was not such that it would allow the employment of space velocities higher than 6.0 volumes of charge per volume of catalyst per hour.

The results of the catalytic polyforming of shale oil at a pressure of 900 psig using n-butane as the outside gas are presented in Runs 15 to 25 of Table 3. Five runs were made at temperatures varying from 385 C to 509 C (725-948 F), using a space velocity of 0.54 to 0.68 hr$^{-1}$ and six runs at temperatures from 392 C to 511 C (738-952 F) using a space velocity of 4.2 to 5.2 hr.$^{-1}$

A maximum yield of 24.4 weight per cent or 27.8 volume per cent gasoline was found at a temperature of 481 C (898 F). This is approximately 3 per cent less gasoline on oil charge than the maximum obtained from a straight catalytic crack; however, the temperature at which this yield occurred was 90 C (162 F) lower than that required in catalytic cracking.

A large decrease in the yield of gasoline from high (4.2 to 5.2 hr$^{-1}$) space velocity n-butane catalytic polyforming runs was noted. The maximum yield of 19.2 per cent gasoline on oil charge is five per cent less than that obtained for the low space velocity n-butane catalytic polyforming runs and eight per cent less than that obtained from

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an atmospheric catalytic crack. This decrease in yield could be a result of the high space velocity not allowing enough time for the n-butane to crack to a hydrocarbon capable of entering into a polyforming reaction with the shale oil.

It was planned to change the catalyst whenever a comparison run showed sufficient loss in catalyst activity; however, in 72 runs with both shale oil and petroleum gas oil at atmospheric and super atmospheric pressures, both with and without an outside gas, the catalyst showed no apparent loss in activity. Approximately 40 liters of various charges have been fed over the one liter of catalyst during the 72 runs. During the use of the catalyst for shale oil research alone, approximately 9500 ml of shale oil and 6000 ml of iso-butylene and n-butane were passed through the 1000 ml of catalyst volume. The final run, No. 72 on the catalyst, showed no drop in activity from that found for run No. 2. Thus, no decline in activity was noted over a period of use of the magnitude reported here.

Table 4 presents the results of the gum tests that were made on the shale oil gasoline samples: It shows the relationship between milligrams of gum per 100 ml of gasoline sample and the per cent conversion obtained when the gasoline sample was made. It is clearly shown that independently of the process by which the gasoline sample was made, the minimum gum content will be essentially the same and will occur at approximately the same per cent conversion on oil charge. The gasoline samples from high space velocity runs will have a slightly higher minimum gum content and will require a higher degree of conversion to reach this minimum.

The results of the laboratory determinations and octane numbers of the shale oil gasoline are presented in Table 5. The losses encountered when the shale oil gasoline samples are given the standardized chemical treatment run from a minimum of 8.4 per cent for low space velocity iso-butylene catalytic polyforming at 460 C (860 F) to a maximum of 13.0 per cent for both straight catalytic cracking at 560 C (1040 F) and high space velocity n-butane catalytic polyforming at 490 C (914 F). These losses would probably be smaller with larger amounts of sample because of a smaller percentage of handling losses. The losses compare very favorably with those found by the Bureau of Mines, who reported losses of 17-18 per cent.

The octane numbers of the shale oil gasoline samples seem to fall fairly well in the same range regardless of the process by which the gasoline sample was made. The octane ratings were de-

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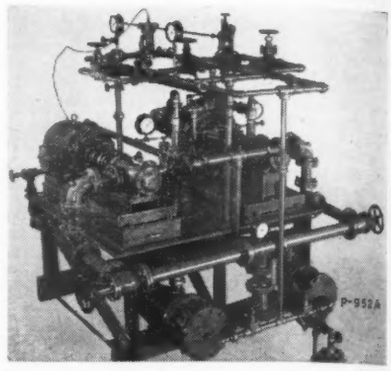

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termined by the method of Alexander and Pfeiffer[1] using small samples, approximately 20 ml for each determination. A definite increase in octane number is noted for the high space velocity iso-butylene catalytic polyforming gasoline over that from low space velocity runs. In catalytic polyforming using n-butane as the outside gas the octane number of the gasoline made at a high space velocity showed a slight decrease from that made at a low space velocity. This high research octane number of the straight catalytically cracked shale oil gasoline can probably be explained by the very high temperature (560 C, or 1040 F) at which the operation was carried out.

In general it can be stated that the octane numbers of gasoline produced from shale oil fall in essentially the same range as the octane numbers of the gasoline produced from petroleum gas oil by the same process under similar conditions.

Shale oil gasoline made by conventional catalytic cracking had extremely poor color stability. Water white on rectification, it always turned opaque black within three to five days. Redistillation failed to alter this characteristic. Gasoline produced from shale oil by catalytic polyforming had excellent color stability. Samples stored in clear bottles on open shelves are a pale amber after four years of storage.

**TABLE 5. Laboratory determinations on shale oil gasoline.**

| Sample number | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|
| Outside gas | Iso-butylene | | None | n-Butane | |
| Space velocity (hr.$^{-1}$) | 0.65 | 4.5 | 0.68 | 0.65 | 5.0 |
| Temp. (deg C) | 460 | 480 | 560 | 480 | 490 |
| Per cent losses with standard chemical treatment | 8.4 | 12.5 | 13.0 | 11.1 | 13.0 |
| Octane number | | | | | |
| Motor method | | | | | |
| Clear | 80.6 | 82.5 | 82.3 | 80.4 | 80.1 |
| 1 ml. TEL | 84.5 | 84.7 | 84.8 | 84.8 | 84.1 |
| 3 ml. TEL | 86.8 | 87.3 | 86.7 | 86.5 | 86.2 |
| Research method | | | | | |
| Clear | 85.7 | 88.6 | 92.3 | 88.1 | 86.9 |

## Conclusions

The following conclusions may be drawn from the results found in this investigation:

1. **Houdry synthetic aluminum silicate fixed bed catalyst is a satisfactory cracking catalyst for shale oil within the temperature limits of the catalyst when about one third of a volume of oil per volume of catalyst is treated.**
2. **There was no detectable loss in the activity after regeneration of the catalyst in straight catalytic cracking or catalytic polyforming of shale oil at 900 psig using either iso-butylene or n-butane as the outside gas after usage amounting to 15 volumes of charge per volume of catalyst.**
3. **Iso-butylene catalytic polyforming gives a definite increase in gasoline yield on oil charge over that obtainable from a conventional catalytic crack and allows the attainment of a space velocity approximately ten times that used in normal petroleum catalytic cracking.**
4. **n-Butane catalytic polyforming gives no increase in gasoline yield on oil charge over that from a straight catalytic crack.**
5. **Catalytic polyforming appreciably lowers the temperature at which the maximum yield of gasoline can be obtained.**
6. **Catalytic polyforming using either iso-butylene or n-butane as the outside gas has little or no effect on the minimum gum content of the shale oil gasoline produced.**
7. **Catalytic polyforming has little or no effect on the octane number of the gasoline produced even though it increases the gasoline yield considerably.**
8. **Catalytic polyforming enhances the color stability of shale oil gasoline.**


## Acknowledgment

The authors acknowledge with thanks the courtesy of the Phillips Petroleum Company, Bartlesville, Oklahoma, who sponsored the fellowship under which this work was carried out and supplied the outside gases used in this investigation. They also acknowledge the courtesy of the U. S. Department of the Interior Bureau of Mines Petroleum and Oil-Shale Experiment Station, Laramie, Wyoming, who supplied the shale oil used in this investigation and for making the octane number and other laboratory determinations on the gasoline samples.


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1. Alexander, J., Jr., and Pfeiffer, C., The Microdetermination of the Knock Characteristics of Motor Fuels, Paper presented before Petroleum Division, American Chemical Society meeting, San Francisco, April (1949).
2. Berg, Mayfield, Saner, Polich, Ennenga, Hamilton, Lewallen, and Crecelius, *Petroleum Engineer*, Vol. XXV, No. 10, p. C-7, Sept. 1953.


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REFINING AND PETROCHEMICAL

# PERSONALS

▸ **C. Calvin Naylor** has been named assistant to Sun Oil's Marcus Hook refinery manager W. T. Askew.

**Walter C. Huffman** was named assistant superintendent in charge of petrochemicals.

Naylor, who served as operating assistant in the catalytic, gas, and alkylation division, joined the company in 1934. He is a chemistry graduate of Pennsylvania State University.

Huffman, formerly general foreman of the new petrochemical Plant 17, joined Sun in the development laboratory at Marcus Hook in 1942.

Huffman was graduated from Purdue University in 1935 as a chemical engineer.

Named to the post of operating assistant in the catalytic, gas and alkylation division is **William J. Devonshire, Jr.,** formerly general foreman at 16 Plant. Devonshire joined Sun in 1932 as a test boy in the refinery laboratory, working up the ranks.

Succeeding Huffman as general foreman at Sun's new petrochemical Plant 17 is **Calvin Stubbs,** formerly supervisory foreman there. Stubbs began his Sun Oil employment as a laborer in 1931.

▸ **Wallace F. Armstrong,** who has been manager of Ethyl Corporation's Houston plant since 1951, has been promoted to the newly established position of assistant general manager of manufacturing with offices at the Baton Rouge plant. A graduate of the University of Florida, he joined Ethyl in 1939.

**Glenn O. Hayes,** acting assistant plant manager at Baton Rouge, has been named Houston plant manager. He has served at both plants in recent months, as acting plant manager at Houston and as acting assistant plant manager at Baton Rouge. A graduate of Milwaukee College of Engineering he came to Ethyl's Baton Rouge plant in 1938.

**James J. Bergin,** superintendent of operations at Houston, moves up to the newly established position of assistant manager of the Houston plant. Bergin has also had wide experience at both plants. He came to Baton Rouge in 1937 as an operating supervisor. He is a graduate of the Catholic University of America in chemical engineering.

**Melvin C. Hudgins,** acting manager of maintenance and on-plant construction at Baton Rouge, has been named assistant manager of the Baton Rouge plant. **Roy N. Clothier** will continue as manager of the Baton Rouge plant.

▸ **Richard E. Putscher,** a research analytical chemist, has been named recipient of the Award of Scientific Merit at Armour Research Foundation of Illinois Institute of Technology, Chicago. He received the prize for his original research work on the isolation of olefins from Bradford (Pennsylvania) crude oil.

The award, established last year, is presented by the Foundation's chemistry and chemical engineering department for "outstanding individual scientific accomplishment." The work cited must be original and must either be in use or capable of being placed in used without further modification or research.

▸ **James F. McNamara** has been elected chairman of the board and president of Alox Corporation of New York, producers of petrochemicals. This follows the recent purchase of control of Alox by Surpass Petroleum Limited, of Toronto, of which McNamara is chairman of the board. McNamara resigned on December 31, 1953, as a vice president of The International Nickel Company.

▸ **Julius O. Fifer** has been appointed to operations in the Philippines by California Texas Oil Company, Ltd. The appointment, made in connection with the new Caltex refinery under construction at Batangas, south of Manila, involves residence in the Philippines, where Fifer becomes vice president and director of Caltex (Philippines) Incorporated.

Fifer's work began in the oil business in 1925 and has been highlighted since by research and refining responsibilities in Texas, at Bahrain in the Persian Gulf, and New York.

▸ **Dr. Bruce H. Sage,** professor of chemical engineering at the California Institute of Technology, was honored recently by the American Institute of Mining and Metallurgical Engineers "for his distinguished achievements in research." He was presented the Anthony F. Lucas Gold Medal Award for 1954 at the annual banquet of the Institute in New York.

Professor Sage was graduated from New Mexico State College and received his MS and PhD degrees from Caltech, the latter in 1934. He became a Caltech research fellow that year and after several promotions was made professor of chemical engineering in 1944.

▸ **D. J. Winter** and **D. L. Campbell** have been appointed vice presidents of the British American Oil Company Ltd. Winter becomes vice president — marketing, and Campbell becomes vice president — manufacturing.

Winter joined B-A's Manitoba division in 1935. Campbell joined British American Oil at Moose Jaw refinery in 1934. He was manager of Calgary refinery before being promoted to manager of refineries in 1948.

▸ **Dr. James H. Gardner** has been named assistant director of the petrochemicals department, National Research Corporation. Dr. Gardner joined the National Research Corporation staff in 1951 as a project manager. Prior to that time he was employed by the Shell Oil Company as a technologist in the company's Houston refinery.

▸ **William D. Thomas** an authority on chemical addition agents for petroleum products, has been appointed to the staff of Southwest Research Institute. In announcing the appointment, Dr. Louis Koenig, associate director of the institute, said Thomas would serve as fuels and lubricants technologist for the department of chemistry and chemical engineering.

Holder of numerous patents on lubricating oil and fuel additives, Thomas came to the nonprofit, industrial research laboratories from American Cyanamid Company's Petroleum Chemical Department in New York City.

▸ **Elfried F. H. Pennekamp** and **Harold J. Rose** have joined the staff of Standard Oil Development Company's new Enjay Laboratories Division. Pennekamp, who was a section head in the research division, will have the responsibility for the technical service activities in the field of the company's additives. Rose, formerly a section head in the Esso Laboratories of Esso Standard Oil in Baton Rouge, Louisiana, will be in charge of sales technical service work on alcohols and other chemicals. They will be at the Esso Research Center.

▸ **Dr. Gustav Egloff,** director of research for Universal Oil Products Company, will receive the 1954 Carl-Engler-Medaille, Germany's highest award in the field of mineral oil science.

Announcement of Dr. Egloff's selection as the first scientist living outside of Germany to receive the award was made by Prof. G. Schlicht, president of the German Institute of Petroleum and Coal. Dr. Egloff will receive the medal in October during the institute's annual congress to be held in Essen, West Germany. He will address the congress on "Chemistry in the Modern Oil Industry."

▸ **Wilburn T. Askew** has been appointed general manager of Sun Oil Company's refinery at Marcus Hook, Pennsylvania. He succeeds Charles E. Maschal who died suddenly on February 17 following a heart attack. Askew joined Sun Oil Company in 1931 immediately after graduation from Texas A & M.

He continued as a chemical engineer in research and development department at Marcus Hook refinery until 1943 when he was made foreman of a large refining unit built during World War II to make aviation gasoline for the Armed Forces. He became assistant manager in July, 1952.

▸ **Henry M. Wogisch,** purchasing agent of L. Sonneborn Sons, Inc., has been elected chairman of the Petroleum Committee of The Packaging Institute, Inc. He succeeds **A. Douglas Murphy** of Esso Standard Oil Company. Wogisch has been active in The Packaging Institute for years.

▸ **Dr. Samuel Epstein** has been promoted to associate professor of geochemistry at the California Institute of Technology by the Board of Trustees. His promotion from senior research fellow is effective July 1.

Dr. Epstein is known particularly for his work in paleo-temperature determinations and for his investigations of oxygen-isotope ratios in waters of various origins. He is currently investigating the isotopic composition of the lighter elements in nature and their contributions to solving some geologic problems.

▸ **Dr. W. H. Bowman** has been named vice president, operations, and **Dr. Max Neuhaus,** vice president, development, Jefferson Chemical Company, Inc. Dr. Bowman is responsible for current operations of the company dealing with the manufacture of its regular products.

Dr. Neuhaus is responsible for activities dealing with the development of new products to the point where they are turned over to operations for commercial manufacture. His responsibilities include the company's research laboratories at Austin, Texas.

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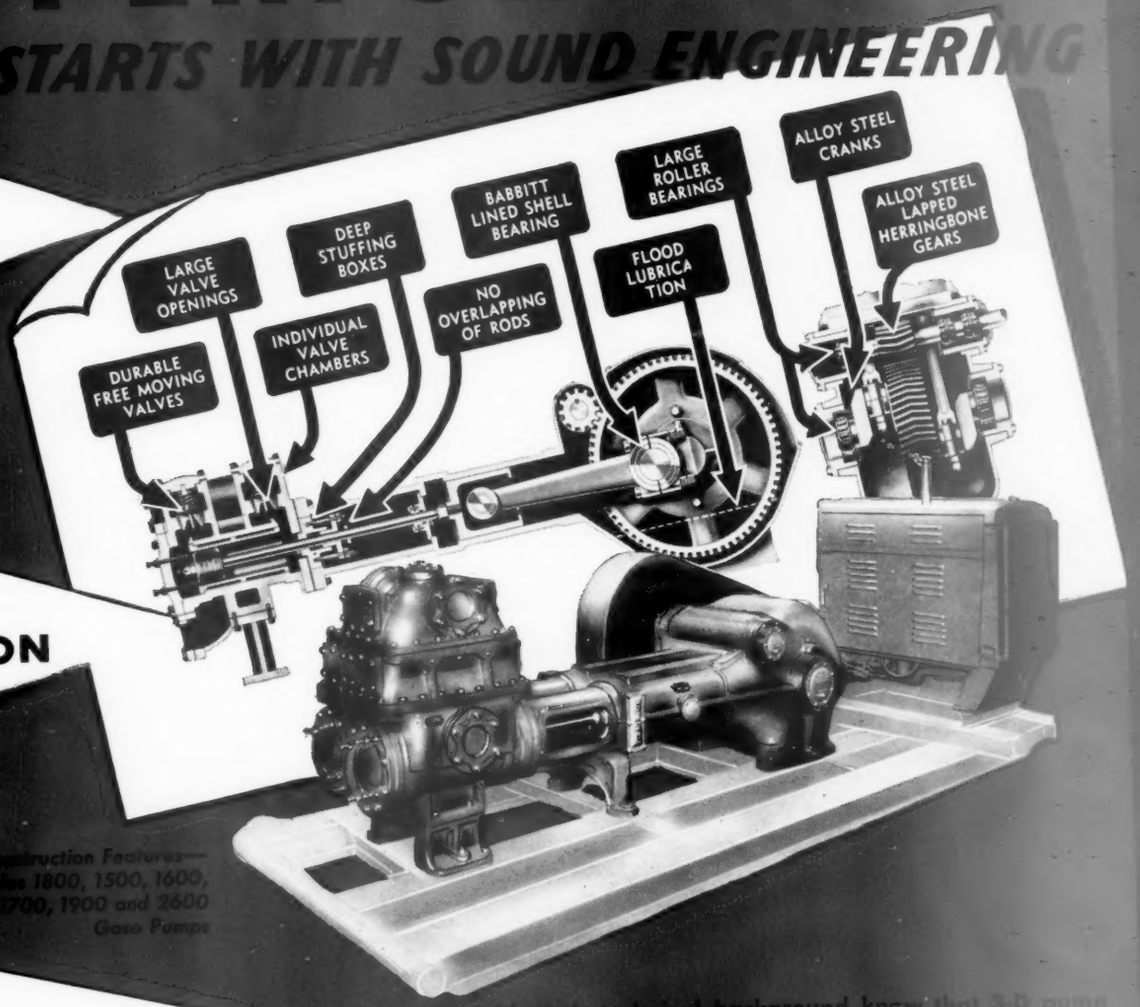


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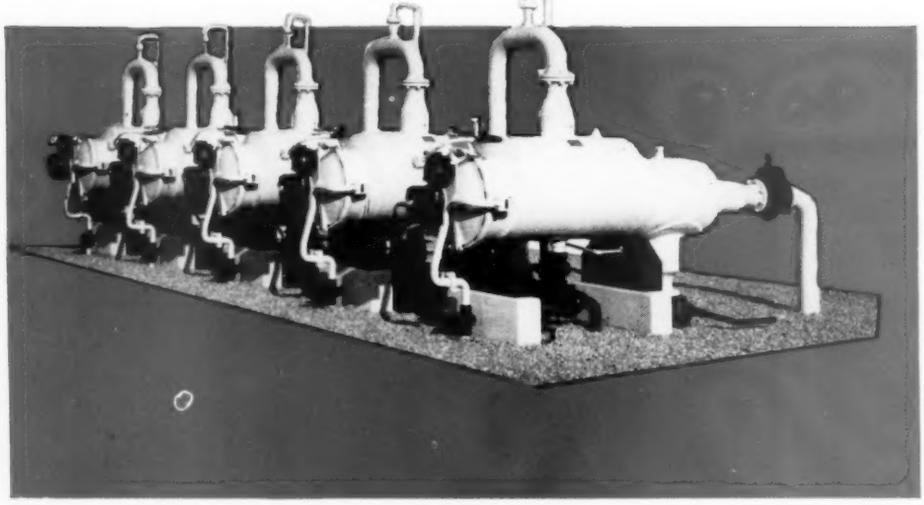
# Pipeline Strainer "Clean-up Crew" at work

When a products pipeline strainer is needed most . . . immediately before a scraper arrives . . . you can depend on Thornhill-Craver Jet Type Fluid Strainers to **stay in there and pitch,** no matter how dirty the product may be. And you don't have to by-pass or back-wash with Jet Strainers in the line. Furthermore, there are no dirty, time-consuming strainer elements to be removed, cleaned, and reinstalled.

Jet Type Fluid Strainers are being acclaimed by everyone who has used them as a noteworthy advancement in pipeline operation. These strainers utilize a stainless steel wire cloth, of any desired mesh, spot-welded to a slotted stainless steel basket. When the basket needs cleaning, as indicated by a pressure differential gauge, it is subjected to high pressure flow through a series of jets mounted on a revolving head within the strainer. The entire cleaning operation requires only from three to five minutes. Stand-by strainers receive the flow while dirty strainers are being cleaned.

Interested operators are invited to write for complete details on these revolutionary strainers.



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*the only strainers that clean all the product all the time!*

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**HOUSTON, TEXAS**

### Pipeliners Commended

A Sun Pipe Line crew has been commended by Pennsylvania Civil Defense Director Richard Gerstell for its action in laying an emergency water line to relieve a drought-stricken western Pennsylvania community. Shortly after Christmas, Bedford, Pennsylvania, faced a critical water shortage due to a long continued lack of rain, and was declared in a state of emergency. State Civil Defense obtained portable pipe and emergency pumps from Federal stockpile at Pittsburgh and assumed responsibility for laying an emergency water line from the Juniata River to the Bedford Reservoir. A serious manpower shortage was encountered, and Sun Pipe Line officials volunteered the services of an eight-man pipe line crew and equipment to help meet the emergency. The experienced pipeliners promptly completed the laying of the emergency water line.

★ ★ ★

### Gas Reserves High

Natural gas reserves in the U. S. at the end of 1953 totaled 211.4 trillion cubic feet, an increase of 11.7 trillion cubic feet over reserves of 199.7 trillion cubic feet a year earlier, a joint report of the committee on reserves of the American Gas Association and the American Petroleum Institute, states. This was the largest increase in proved recoverable reserves since 1946. These reserves achieved a new record high level after an all-time high production of 9.2 trillion cubic feet of natural gas used in 1953. Previous record production was 8.6 trillion cubic feet of natural gas in 1952.

Discovery of 7.1 trillion cubic feet of new natural gas reserves in 1953 as compared with 5.4 trillion cubic feet in 1952, emphasizes important increase in exploration activities. Exploration and drilling in existing fields added another 13.4 trillion cubic feet to the nation's proved recoverable reserves of natural gas.

Nearly 516 billion cubic feet of natural gas were added to estimated reserves in underground storage at the end of 1953.

★ ★ ★

### New Texas Tax Seen

A new tax on natural gas "long lines" is expected from a special session of the Texas state legislature, replacing the "gathering tax" ruled unconstitutional by the United States Supreme Court.

Two proposals have been made, one a new "gathering" tax placed on gas as it leaves the well. Such a tax would bear primarily on pipe line companies.

The other proposal would be a tax on gas produced under contracts longer than one-year, a form of "dedication" tax that would be aimed primarily at pipe lines and industrial users. Present production taxes produce $4,000,000 revenues for the state of Texas.

### Texas-California Line Aid?

A military report on necessity and feasibility of a Texas-California crude oil pipe line is expected soon, and rumors are that report will favor such a project, but will not endorse any specific project now being proposed.

West Coast Pipe Line, headed by L. M. Glasco, Dallas, Texas, has applied for a certificate of necessity and has asked for federal aid in underwriting an $85,000,000 bond issue that will be needed. Glasco wants government assurance against a 75,000 bbl daily, 60 cent rate for earnings, the "break even" point. Glasco said there is $21,500,000 equity capital available to build the line if an assurance is given.

★ ★ ★

### New Gas Line Map

A new map of major natural gas pipe lines, as of December 31, 1953, has been issued by the Federal Power Commission. The 4 color, 13 by 19-in. map is printed on a scale of 165 miles per inch, and is available from the FPC, at 25 cents per copy.

★ ★ ★

### African Job Successful

Collins Construction Company, Port Lavaca, Texas, has finished a successful launching of 11,500 ft of 12⅝-in. gunnited pipe at Accra, British West Africa. This venture was under contract to Taylor Woodrow, Ltd., London.

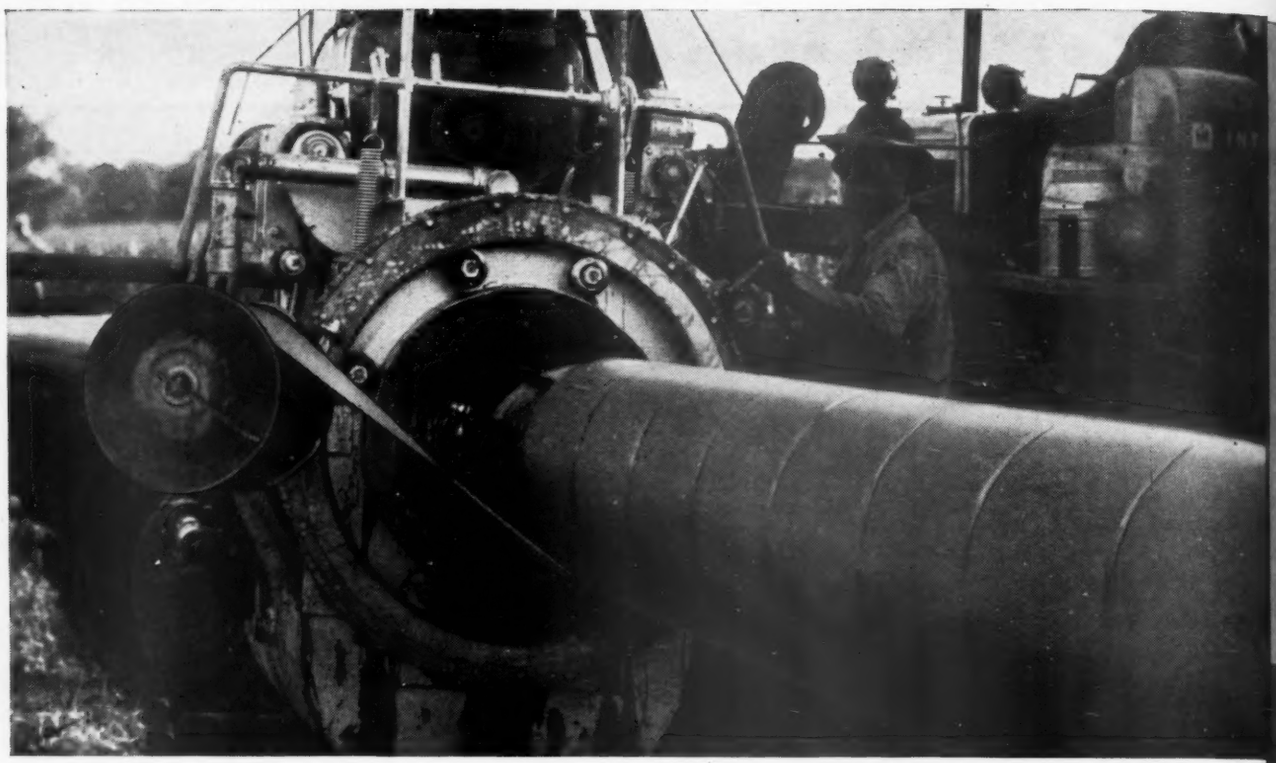
**IN MAY**

**ANNUAL PIPE LINE PROGRESS ISSUE**

What's new in the pipe line industry? Here are the answers in more than 15 carefully selected articles by the leading authorities and pipe line industry experts, summarizing the advances in oil and gas pipelining techniques and methods, including:

Marine Line Maintenance
Field Repair of Scrubbers
Protect Your Electric Motor Investment
Anodes vs. Rectifiers
Incrustation and Tank Capacities
Packaged Pump Units
Soil Conservation, A New Philosophy in Back Field Maintenance
Microwave System Design, Part One of a series

**It's all in your**
***Annual May Pipeline Progress Issue***



## THE REASONS BEHIND THE PREFERENCE FOR NO-OX-ID

In addition to their superior protective qualities, there are many reasons why NO-OX-ID pipe coatings and NO-OX-IDized wrappers are preferred.

**LIGHTER WEIGHT**... NO-OX-ID weighs less and covers more pipe footage—thus providing substantial savings in handling costs.

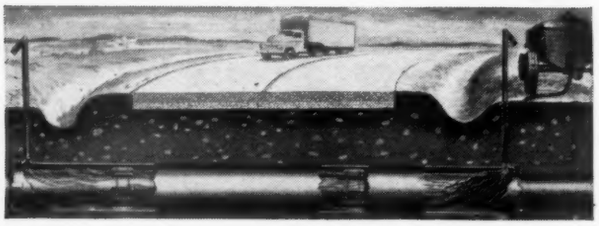
**CHOICE OF APPLICATION METHODS**... NO-OX-ID can be applied by hand over rough terrain or on short line jobs—by Traveliner on long lines—at the mill or yard by many independent applicators and utilities.

**SAVES ON LABOR AND MATERIAL**... NO-OX-ID handles easier—coating more feet of pipe per man-hour because less material is required. Fewer "dope" kettles, trucks and "cats" are needed.

**COATING CREWS PREFER NO-OX-ID**... because there are no irritating or noxious fumes, coating crews like working with NO-OX-ID.

Write for booklet "Protecting Underground Pipe from Corrosion" for detailed information on NO-OX-ID combinations.

## *Dearborn* NO-OX-ID CASING FILLER FOR PIPELINE CROSSINGS



**Write For Bulletin 3079.**

NO-OX-ID CM Casing Filler protects against corrosion wherever pipelines are cased beneath highway and railroad crossings. More than just an oil or petroleum product, it (1) contains additives; inhibitors and wetting agents; (2) has water displacing properties up to 5% its own weight; (3) is applied at 150° temperature, solidifies to a firm jell, completely sealing off the annular space, but permitting detection of leaks; (4) serves as an electrical insulator; (5) is economical to apply.

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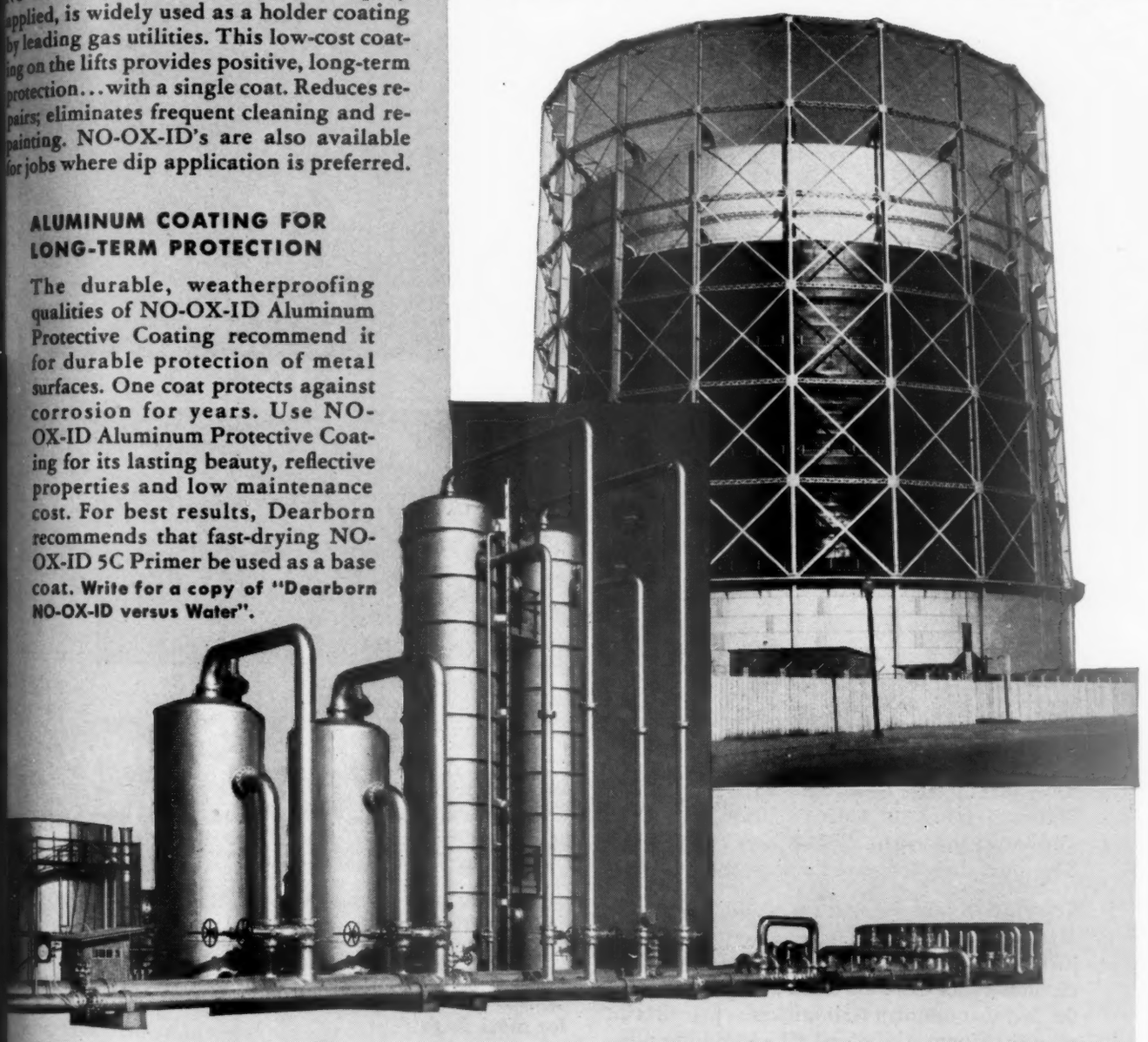
The durable, weatherproofing qualities of NO-OX-ID Aluminum Protective Coating recommend it for durable protection of metal surfaces. One coat protects against corrosion for years. Use NO-OX-ID Aluminum Protective Coating for its lasting beauty, reflective properties and low maintenance cost. For best results, Dearborn recommends that fast-drying NO-OX-ID 5C Primer be used as a base coat. **Write for a copy of "Dearborn NO-OX-ID versus Water".**



### NEWLY ORGANIZED *Dearborn* PIPELINE SERVICE DIVISION

To better serve its many pipeline customers, Dearborn recently organized the Pipeline Technical Service Department to handle technical problems dealing with transmission and distribution systems coating materials. You are invited to take advantage of this added Dearborn service on any pipeline problem. Just call your Dearborn representative.

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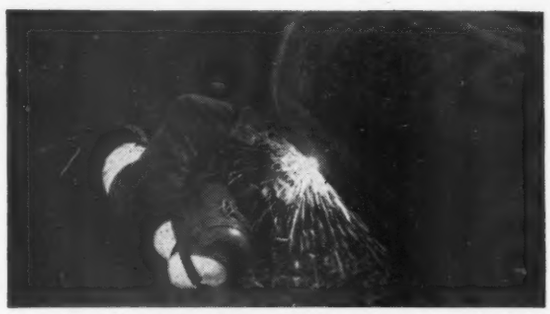
XUM

*Crude oil pipe line from Yale, Okla., to Borger, Tex. This is 10¾" Electric Weld Line Pipe.*

# Here's line pipe that goes in fast in the field



*Field welding joints before ditching Electric Fusion Weld Gas Line from Petersburg, Ohio, to Cleveland, Ohio. Three 60-foot joints were field welded together before coupling.*

Take that Electric Resistance Weld Line shown above. Or a big 30" Electric Fusion Weld Line, shown at the right. When they're made by Republic, they have one thing in common:

**They go in fast**—And it's no accident. Circumference is always constant. That means field joints line up accurately and quickly. The entire circumference can be welded at top speed. Plus the fact that uniform wall thickness provides an even distribution of metal all around the pipe.

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So when you need line pipe for oil and gas transmission, high or low pressure, remember, Republic makes both types—Electric Resistance Weld and Electric Fusion Weld. Also, Continuous Butt Weld Pipe for gathering lines. Write for more facts.

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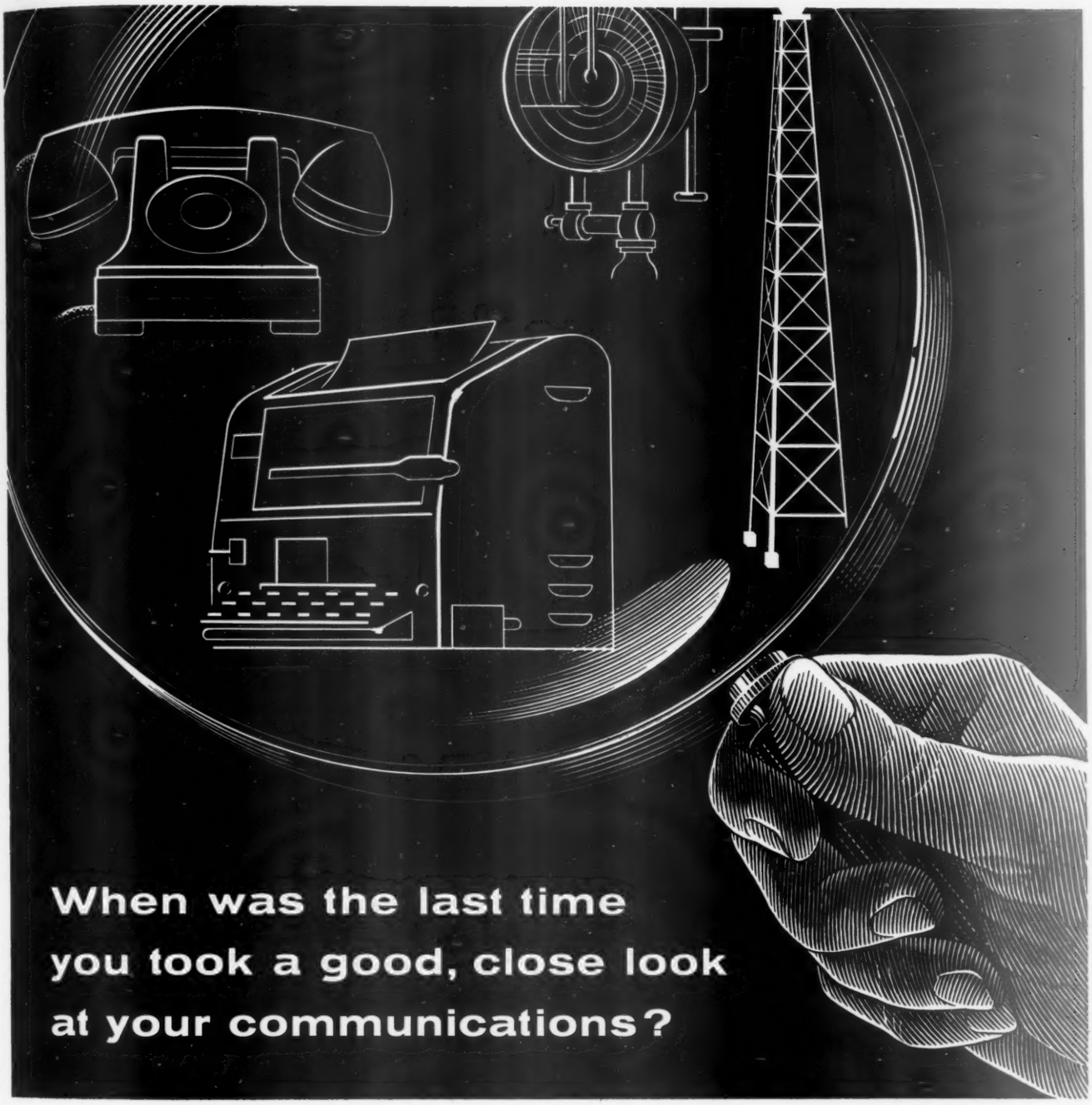

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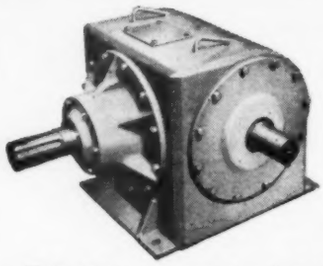
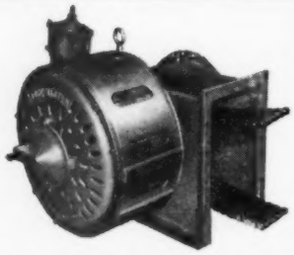
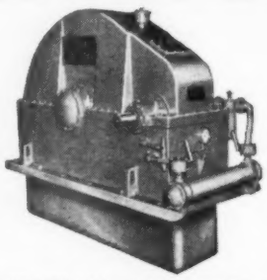


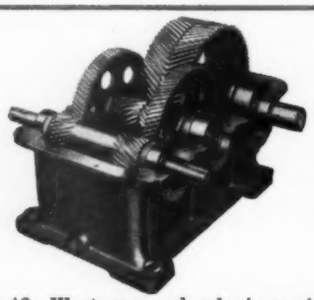
This right-angle gear box is designed for transmitting power to operate a rotary table.



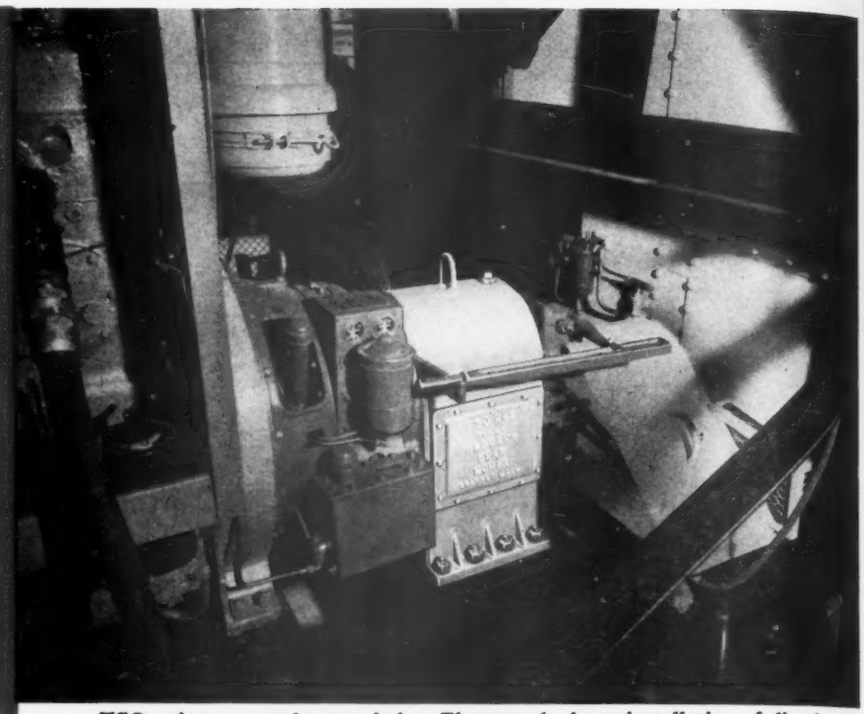
The Torq-Master unit is designed for application to Torque-Converters and can be adapted to Pacific-Western Converters and other leading makes.



Pacific-Western high speed units for stepping-up speed from prime mover to pump.



Pacific-Western speed reducing units for stepping-down speed from prime mover to pump. (Case cover removed.)



TSO unit two speed transmission. Photograph shows installation of diesel engine used to drive rotary table drive.

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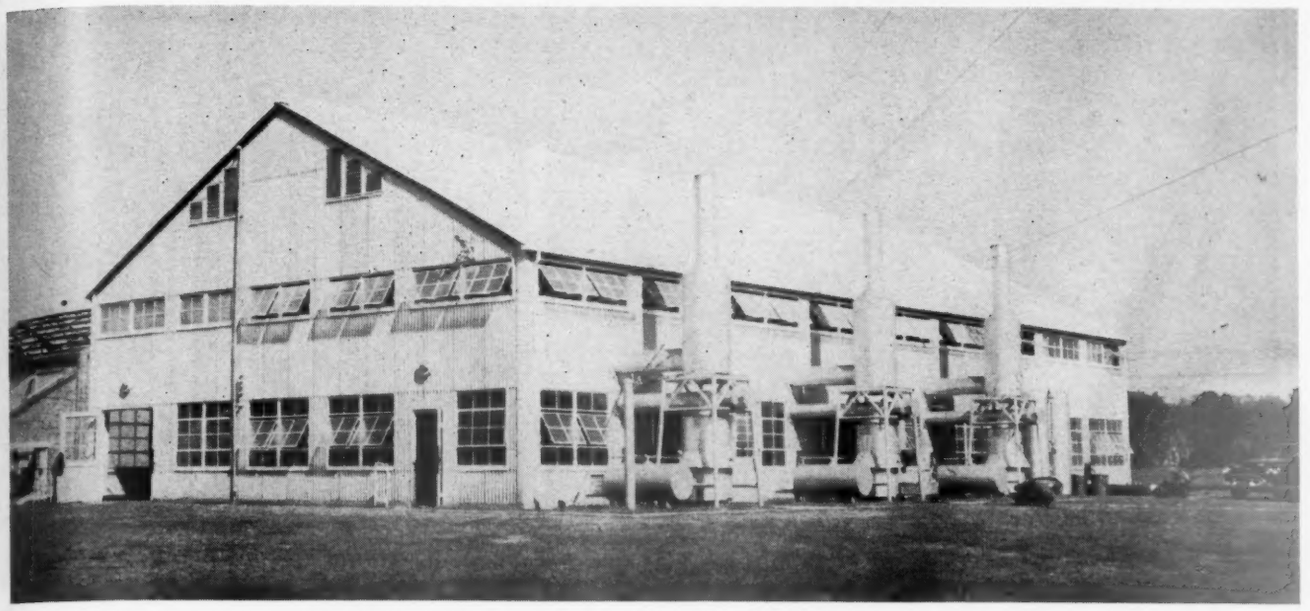


Interstate Oil Pipe Line Company's Bunkie station in central Louisiana. The New Interstate pipe line station was constructed on site of old station erected in 1909.

# Bunkie Station—Modernization Example

*Interstate Oil Pipe Line's new station incorporates latest design, equipment, and continues 44-year service history*

E. C. MISHOU

INTERSTATE Oil Pipe Line Company has recently completed a three year expansion and modernization program on its Arkansas-Baton Rouge trunk line that provides increased capacity of the system, through new lines and two new modern pumping stations.

System modernization includes replacement of 620 miles of 8 through 12-in. pipe with 222 miles of 8 through 22-in. pipe on the Shreveport-Baton Rouge route, with lines routed around urban areas and shortened.

Focal point of the expansion and modernization program is Interstate's Bunkie station, one of two new stations having a total of 8100 hp and three pump units each, which replace six former pumping stations containing 77 units with a total of 13,300 hp. Bunkie is about 70 miles northwest of Baton Rouge, Louisiana.

Improved design in the pipe line system, coupled with more efficient pumping equipment, has eliminated 4 stations on the system, increased daily capacity to 133,000 bbl, and can provide an additional 24,000 bbl per day capacity increase through replacement of the remaining 12-in. lines on the system with 22-in. pipe and additional pump horsepower and tankage at the two new stations.

Bunkie station, first of two to be completed and put on stream, has three modern, 1200-hp, gas diesel engines operating on dual fuel, driving high speed centrifugal pumps.

The other station, just completed, is Finney station, near Shreveport, an all-electric station with three 1500-hp electrically driven high speed centrifugal pump units.

## Bunkie Has Clean, Modern Look

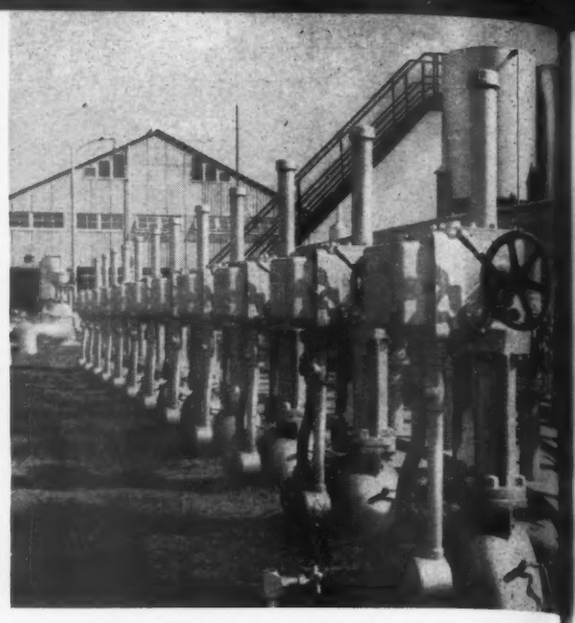
In outward appearance, Bunkie station resembles most pipe line pumping stations in operation today. Immediately noticeable is the bright, clean look of the plant and yard. The station's

EXCLUSIVE

**The Author**

E. C. Mishou, assistant to the division manager of Interstate Oil Pipe Line Company, began his pipelining career as an engineer with the Ajax Pipe Line in 1943. In 1945, he transferred to Interstate as safety engineer at Tulsa, Oklahoma. He was made assistant division chief engineer of Interstate's southern division in 1947 and was promoted to chief engineer in 1948. In 1952, Mishou accepted a special assignment in the office of the Pipe Line Advisor of Standard Oil Company (New Jersey) in New York, returning in 1953 to Interstate as chief engineer. He was recently appointed to his new post. A native of Pueblo, Colorado, he attended Columbia University and later received his bachelor of science degree in petroleum engineering from the University of Kansas.

**Top-side view of manifold, incoming lines located above tank lines, with vertical connectors between. Motor-operated valves at left used on lines between tanks and main booster pumps.**



**Ground view of motor-operated valves, with main booster and station to rear.**

back yard sparkles with a silver and red-trim manifold, well-trimmed grass, and neat appearing tankage area. Concrete walks give easy accessibility to all parts of the yard.

The station has the most up-to-date equipment that can be provided. Motor driven valves at the manifold and tanks are operated from the control room. Operational gaging is no longer a problem in bad weather — merely a matter of flipping a switch and reading dials on the operator's desk. Engine and pump rooms are spotless, quiet in operation compared to the old stations, and good housekeeping provides a place for every tool and piece of equipment.

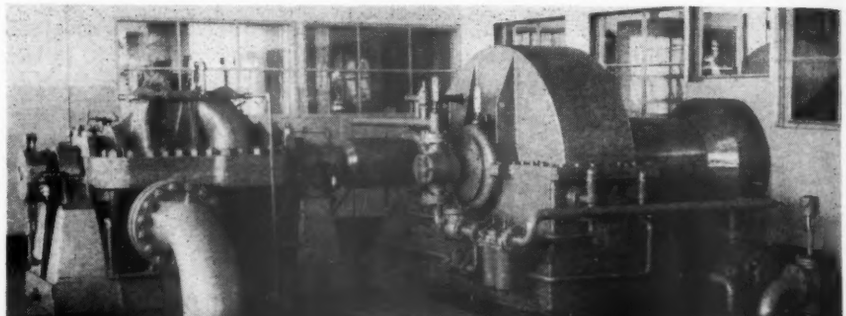
### Old Station History

The first Bunkie was one of the original main line stations of the Standard Oil Company of Louisiana and was in almost continual operation after completion in 1910. The station began operation under supervision of R. P. Lockhart, chief engineer during construction and initial operation and at the time was equipped with three 100-hp pump units with a daily capacity of 10,000 bbl.

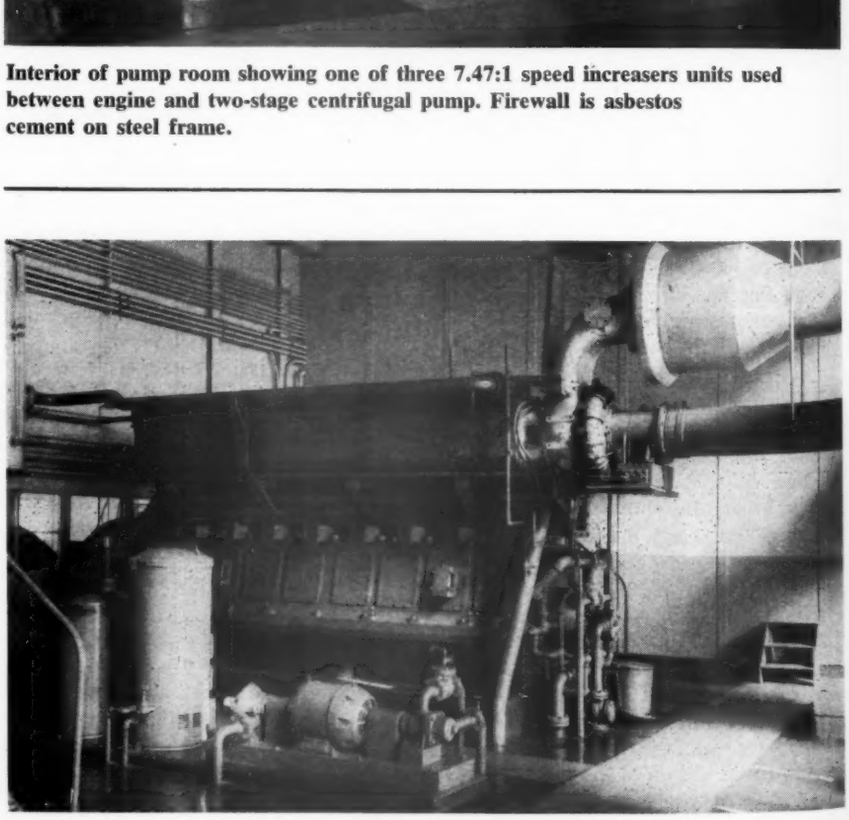
As the oil industry grew in Louisiana, so did Bunkie station. Additional pump equipment boosted capacity in 1911, 1913, 1915, 1921, and 1922. By that time, daily main line capacity through Bunkie's facilities was 108,000 bbl.

During its time, the first Bunkie station pumped over 1,130,000,000 bbl, equal to about 185 days of U. S. production at today's rates.

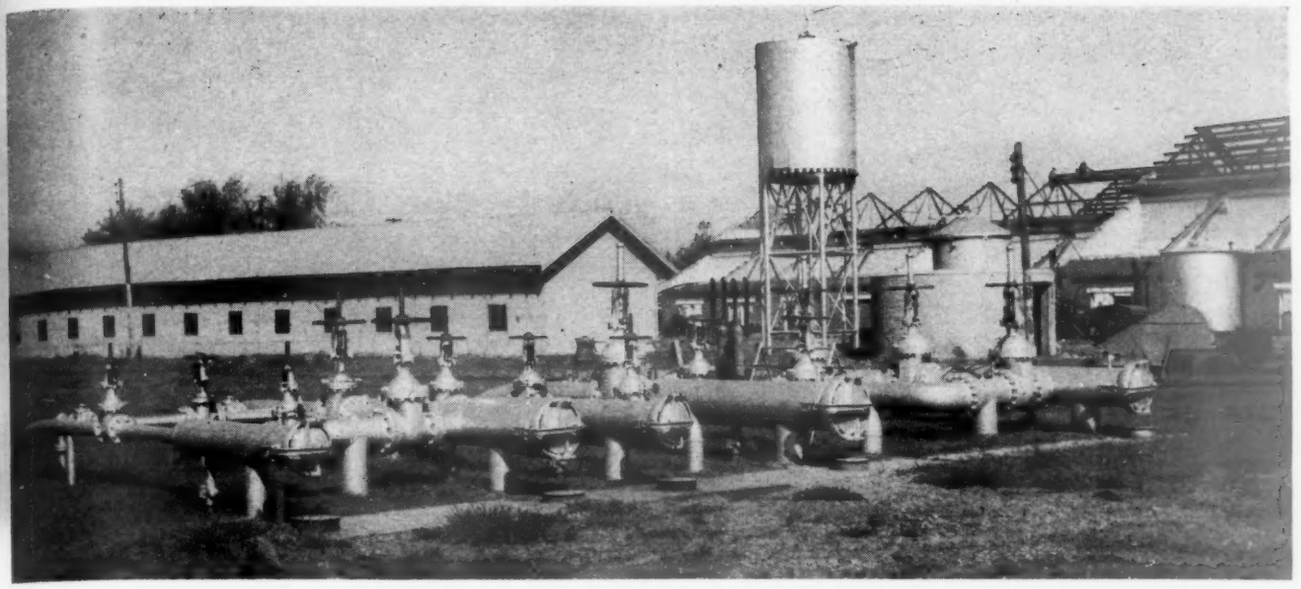
The station has always had an outstanding safety record. More than 26 years operation has been conducted without a lost time accident. In the new station, this record, begun in 1927, is being carried on. A veteran crew mans



**Interior of pump room showing one of three 7.47:1 speed increasers units used between engine and two-stage centrifugal pump. Firewall is asbestos cement on steel frame.**



**1200-hp, turbo charged dual fuel engine used at Bunkie. Three of these are in service at station.**



**Scraper traps are located separately from manifold.**

the new Bunkie station. The 12 men on duty represent more than 350 years of pipe line experience.

### Prime Movers

Three 1200-hp turbo-charged engines designed for dual fuel operation are installed at the station, with all three in use. Standby of the engines is on a per cent of use basis.

Two of the engines operate 24 hours per day, a third operates 12 hours per day. Based on a total operating time of 72 machine-hours per day (3 engines × 24 hours), the engines operate a total of 60 machine-hours, providing 12 hours of spare unit time per day.

The eight-cylinder engines develop their 1200 bhp at operating speed of 450 rpm with a 13-in. bore and 16-in. stroke. Average speed varies from 350 to 450 rpm, depending on crude.

Speed increasers with a ratio of 7.47:1 are connected between the engines and the pump units driven.

For the dual fuel operation, natural gas is purchased and pilot fuel is taken from the crude stream. Two 89-bbl elevated cylindrical tanks with conical bottoms are used for pilot fuel storage, the fuel flowing from the tanks to the engines by gravity flow.

Oil to be used for pilot fuel is diverted from the passing crude stream to a fuel oil centrifuge, pumped from the centrifuge to elevated tank. Manifolding provided on the fuel oil piping allows the oil to be re-run from one tank through the centrifuge for additional cleaning and back to the other.

Starting air is provided at 250 psi by a compressor and two 30-in. by 8 ft vertical cylindrical air storage tanks. Air is supplied to each engine from an air header line. Compressors used are type 30, rated 50 cfm at 250 psi, and driven by 15 hp class I group D electrical motors.

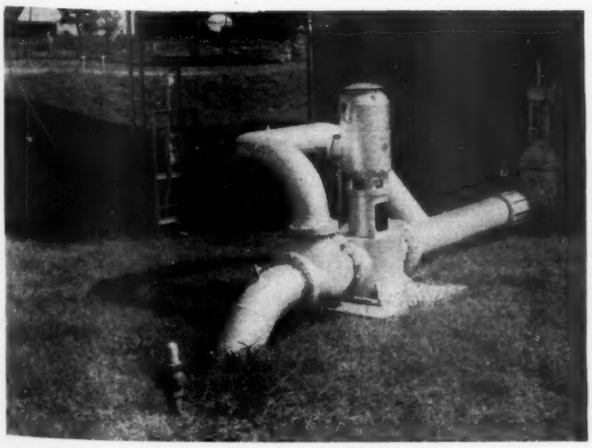
Oil bath filters are provided for the air inlets to the turbo chargers and back fire relief valves are installed to protect the air filters.

Lubricating oil is filtered through cotton waste type packed heated filters on partial flow of the lube stream. New oil is added to maintain the desired level as is necessary. Lube oil is sampled and analyzed monthly, and is changed and discarded when analysis indicates acids, dilution or precipitation has reached predetermined maximum.

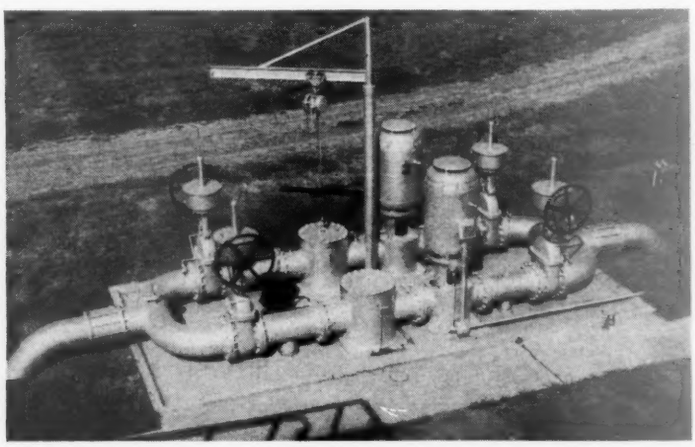
### Auxiliary Electrical Equipment

Two vertical 100 hp, three phase, 60 cycle, 440 v, 1170 rpm class I group D induction motors are used on the main booster pumps. Six similar but smaller motors are installed on the tank booster pumps. Other various smaller electrical motors are used on auxiliary equipment in the station. Power is purchased from the local utility.

Three main pumps in use are of the centrifugal type, 10 × 12 × 13 horizontal split case design, two stage,



**Motor-driven, vertical turbine type boosters use on tank lines to main boosters.**



**Main booster pumps are electrically driven, vertical turbine type, two-stage.**



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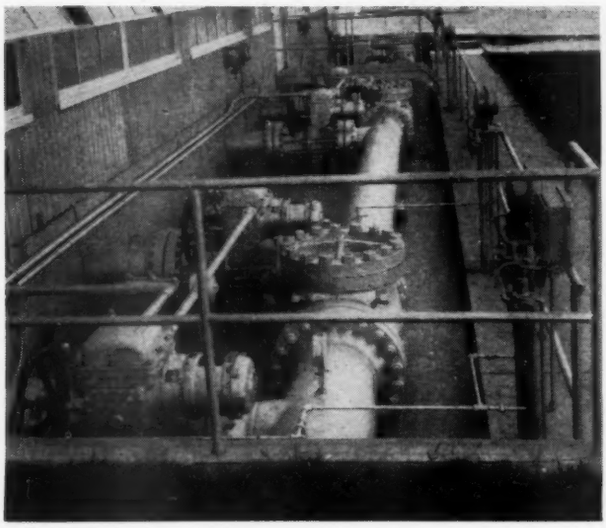
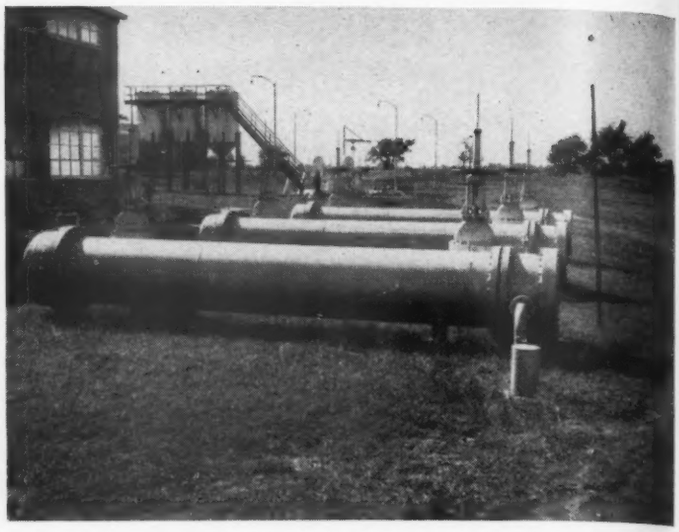


Discharge lines from pump room.



Heat exchangers used to cool circulating engine jacket water.

double suction operation. The station is designed to operate at constant pressure, allowing variable speed and variable pump capacity depending on type of crude being pumped.

Design capacity of station is 160,000 bbl per day on light crudes, 110,000 bbl per day on heavy crudes for an average of 135,000 bbl per day.

Bearings in pumps are lubricated by splash ring in the bearing housing oil reservoir. Bearings and seals are cooled by bleeding from high stage through cooling jackets located outside and discharging to the station sump.

Booster pumps used to maintain suction pressure are 16 × 16 × 22 vertical turbine type, two stage operation. Similar booster pumps are used as tank boosters, but are 14 by 16 by 22 size.

### Station Building

Housing the equipment and offices at Bunkie is a steel frame, 108 by 54 ft building, with corrugated asbestos siding and roof, having a 31 ft, 6-in. ridge height and 18 ft, 6-in., eave height.

Area of the engine room is 32 by 72 ft, and contains engines and all engine auxiliaries. The pump room is 22 by 72 ft, and contains the speed increasers and main pumps.

Office part of the building is 36 by 54 ft, and is divided into two levels. A storeroom for parts, tools, and other gear is maintained upstairs. Downstairs are the operator's office, switch gear room, workshop, washroom, sample testing room, and chief engineer's office.

Electrical equipment in the pump room and engine room is of class I group D design for hazardous locations. A flat asbestos cement firewall on steel frame separates the engine and pump rooms. Steel sash windows are used throughout the building.

Heating in the office end is of the gas furnace, forced warm air type, with ducts provided to all rooms.

Ventilation of the engine and pump rooms is through roof ventilators of the ridge row type. The engine room is also ventilated by jacketed engine exhausts.

### Fire Protection

Only auxiliary building at the station is the shed housing the fire pump and foam system. Foam lines are piped to the pump room from the pump. When rate of temperature anywhere in the pump room exceeds the allowable setting, the fire pump immediately starts, and foam is pumped into the room. Driver on the pump is an electric motor with engine standby.

A hydrant system on the outside of the building can be cut into the foam system any time it is needed.

Additional fire protection equipment consists of a combustible gas analyzer with 12 sensing points located in various parts of the engine and pump rooms. Presence of combustible gas sounds an alarm to the operator.

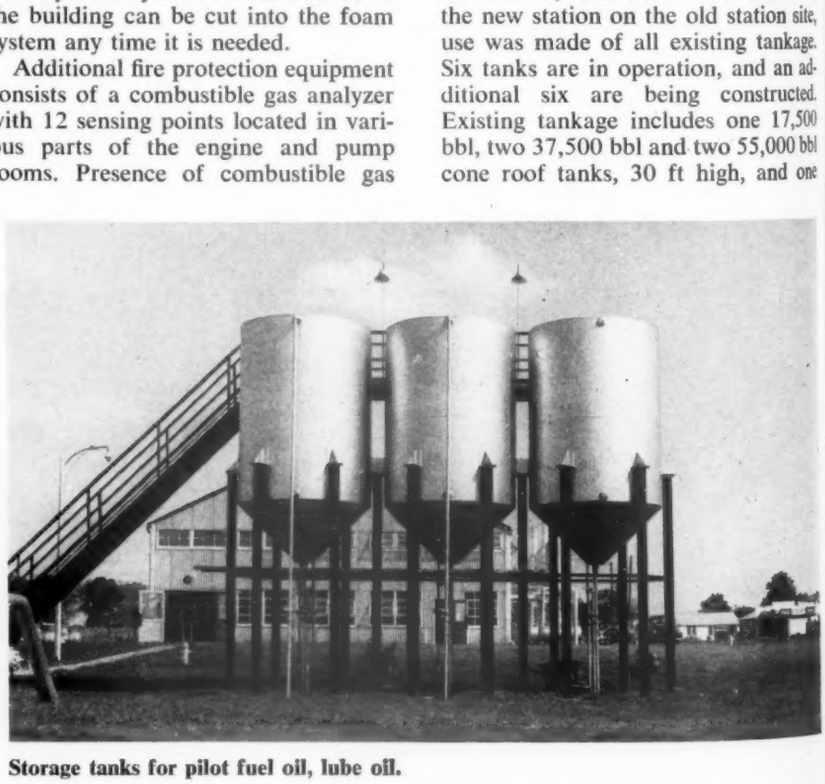
### Station Manifolding

All manifold piping is located outdoors, with incoming stream lines located directly over tank lines with connecting vertical risers. Design of the manifold provides full flexibility in diverting any incoming line to any tank line and for movement between tanks.

Incoming and outgoing scraper traps are separated from the manifold, located some distance away. A relief line is provided only from incoming scraper traps.

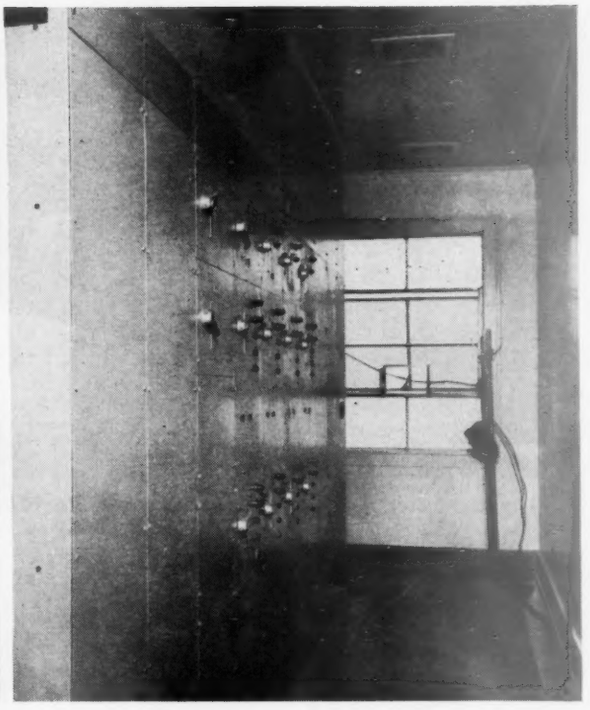
### Working Tankage

Only working tankage is provided at the station, and with construction of the new station on the old station site, use was made of all existing tankage. Six tanks are in operation, and an additional six are being constructed. Existing tankage includes one 17,500 bbl, two 37,500 bbl and two 55,000 bbl cone roof tanks, 30 ft high, and one



Storage tanks for pilot fuel oil, lube oil.

Operator's desk in station control room. Left is panel showing operating conditions of lines, valves, tanks. On desk are station pressures, temperatures, remote tank reading gages, selector switches.



Control board for electrical equipment.

55,000 bbl butt welded floating roof tank 40 ft high.

New tankage under construction includes two 55,000 bbl and four 80,000 bbl welded, double deck floating roof, 40 ft high, tanks.

Mechanical propeller type mixers are being installed in all tanks to prevent accumulation of BS&W.

### Gaging

Remote reading gages have been provided between the operator's office and tank yard, and are single selsyn type with a reset feature in event of power failure. A single dial type gage in the operator's office reads feet or inches. A selector switch allows operator to select any tank he wishes to read.

Through this method, the operator can maintain a continuous check on the fill of tank or tanks from the incoming stream, and at the same time, check the outflow from other tanks into the discharge stream.

The station is designed to stop the stream when all work is completed — that is, delivery is made to one tank, and suction from another. Some oil is received into the system at Bunkie and is measured by hand gaging. Daily inventory checks and checks of remote readings are also made manually. Operational checks are made by the remote reading gage.

### Station Control and Operation

The control system at Bunkie, and engine-driven station, was designed to control only the operation as a discharge station. Switching of various incoming streams to the desired tankage is manual. With the oil in the tank and ready to be pumped out, the operation is then remotely controlled from the station control panel in the operation office.

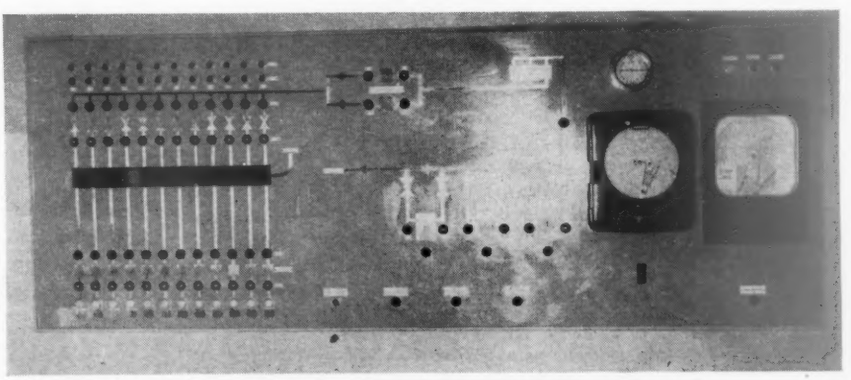
With the units checked and cleared for operation, the operator pushes the "Open" button for the tank to be pumped out. This starts the manifold tank valve opening. The tank booster unit will start, unless the tank liquid level is above a predetermined height. The main booster unit also starts, and when sufficient suction pressure is available at the main pumps, the low suction pressure indicator will go off.

The engine is then started and providing it is cleared for operation, runs at idling speed. Pump discharge valve is opened by moving a selector switch on the engine panel to "run" position.

After the engine has reached operating temperature, it is brought up to speed by opening the manual speed regulator. Engine speed in operation is controlled by pneumatic system to hold predetermined discharge pressure.

Rates of flow of crudes handled vary widely because of difference in viscosity and gravity. Crude characteristics handled vary from 45 SUS viscosity and 43 API gravity for the light crude batches to 500 SUS viscosity and 26 API gravity for the heavy crudes.

As a result of the difference in the batches, flow conditions within the pipe line are changing constantly. The variable flow conditions that result were the basis for the design of the station at constant pressure, rather than constant volume, giving the most efficient performance possible. * * *



View of control panel in operating office. Light indicates functions currently in operation.



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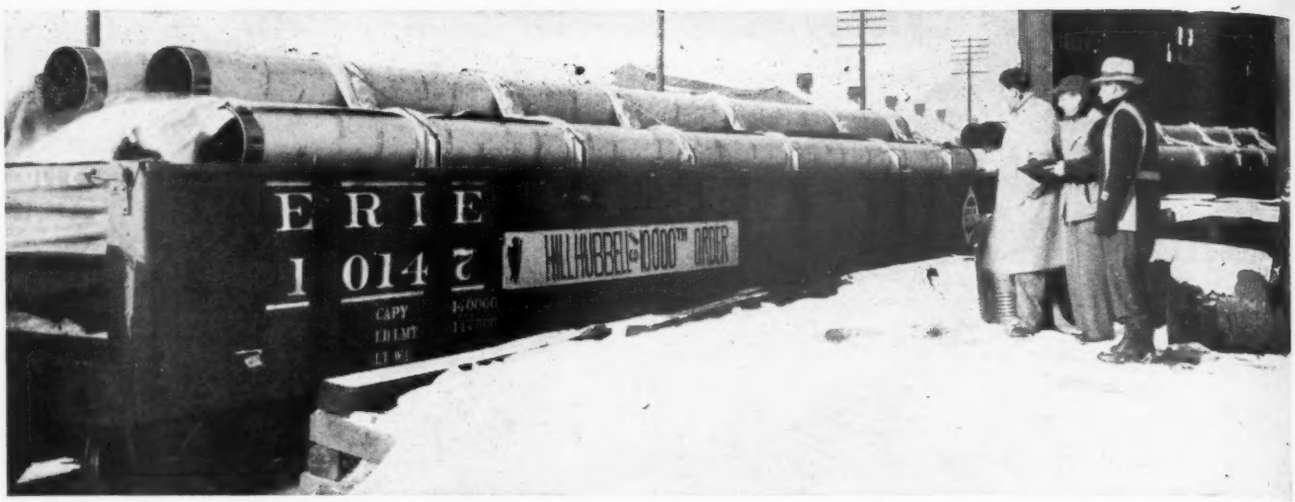
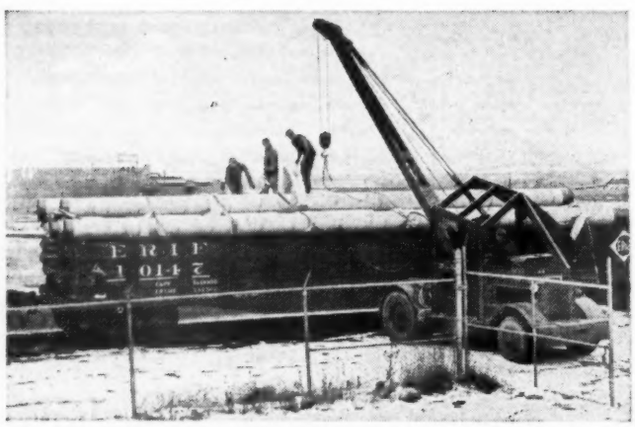



*The first installment of Hill, Hubbell Order No. 10,000 leaves our Girard (Ohio) Plant for shipment to a public service company in Colorado. This order consisted of 12 carloads of 20" pipe for a supply line in Denver. Through the years, Hill, Hubbell shipments have ranged from single carloads to whole trainloads of coated and wrapped pipe.*

# We're already busy on the next 10,000




*Here the first carload (Erie 10147) of Hill, Hubbell Order No. 10,000 is being unloaded by workmen of the Public Service Company of Colorado in Denver. On time, as usual.*

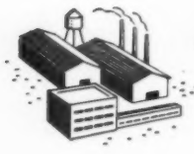
Here at Hill, Hubbell we have completed and delivered our 10,000th order of factory coated and wrapped pipe, and are confidently working on our next 10,000 jobs.

We learned a lot of pipe wrapping "know how" on our first 10,000 jobs. We learned a lot, too, from our many customers since we originated the first mill wrap process over a quarter of a century ago.

Frankly, in this business of coating and wrapping pipe, there is one very important ingredient money can't measure — and that is experience. All we ask, here at Hill, Hubbell, is that we be permitted the privilege of proving to you the advantages of experienced pipe wrapping "know how" on your next order of mill wrapped pipe — regardless of the size of the job.

To our hundreds of valued customers in all the 48 states, we say —"Thanks for the first 10,000".

**THREE HILL, HUBBELL PLANTS TO SERVE YOU:**



**GIRARD, OHIO**
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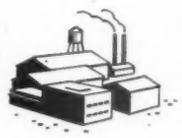

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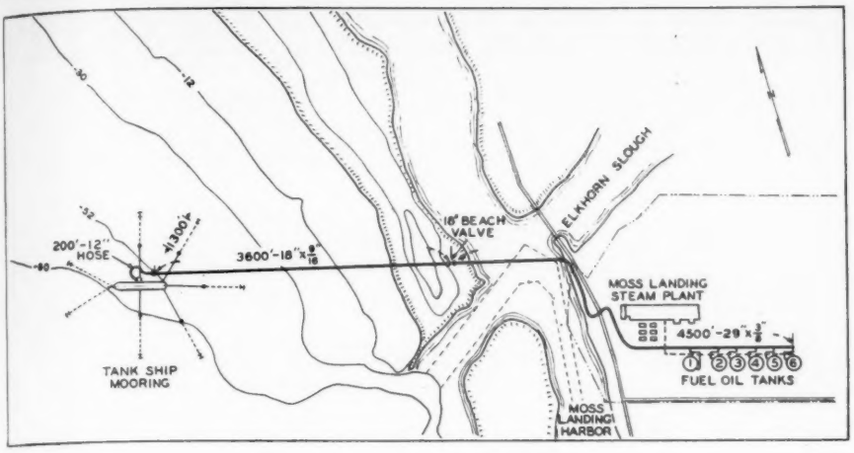


**FIG. 1. Layout of unloading line.**

# Submarine Line Delivers Fuel Oil From Offshore†

*High viscosity and high temperature of product presented unusual design and operating problems*

S. P. JOHNSON and E. A. SALO

IN the past, location of the steam power plants of the Pacific Gas and Electric Company have been such that pipe line or dock facilities in protected waters have been available. Site of the Moss Landing steam plant required delivery of fuel from the open California Coast. This necessitated deep water moorings for large tank ships.

Submarine pipe lines for transferring oil have been in use on the California Coast for a number of years, but mainly by oil refiners or producers. In most cases, the products handled were crude oils of low viscosity. The Moss Landing installation, however, required the transfer of bunker fuel of 175 SSF viscosity at 122 F, and later, the viscosity was increased to 200 SSF. This brought up problems that were not previously encountered.

One of the limitations presented to the designers was a temperature of 135 F, considered at the time to be the maximum advisable without overstressing the hulls of the ships. Much higher cargo temperatures have been tolerated elsewhere in ships carrying asphalt, but with special precautions and admittedly high temperature stresses.

## Shore Layout

The shore equipment, which is shown on Fig. 1, consists of six 120,000 bbl tanks. The tanks are provided with external heaters and both transfer and recirculating pumps. When necessary, temperature is maintained by recirculation. Pipe lines in the plant are 14-in. diameter and are steam traced and insulated.

The main delivery system, designed to take the maximum pumping rates is larger. It consists of 3600 ft of 18-in. OD, 9/16-in. submarine line, and 4500 ft of 24-in. OD pipe line on land. These lines were designed to receive approximately 10,000 bbl per hour of oil from tank ships.

The heavy wall thickness of the 18-in. line was provided primarily to permit the coated line to sink when empty, a necessity with the laying operation used, in which the line is assembled on small carriages on a track on shore and towed out along the ocean bottom. This has been the standard method of installation on the California Coast. Except in very quiet waters, other methods have proved hazardous if not impossible. The alternative to heavy pipe would be external weights which would not cost less and might interfere with the progress of the line along the bottom. The 24-in. line, all on land, was installed by conventional means.

Underwater part of the pipe line is coated with Somastic pipe coating 5/8-in. thick. This is an extruded coating, 88 per cent of which is washed and graded sand with other mineral filler, and 12 per cent of which is bituminous binder. This type of coating had proved to stand up very well under sea water, an environment considerably more severe than that encountered under ground.

The stationary underwater line terminates in a transition member that necks down to a standard 12-in. flange. A blanked-off 8-in. tee was provided for a circulating connection if needed. These details are shown in Fig. 4. The sled shown was used in hauling the line into position and now serves to keep the connection from burying itself in the sand.

The flexible hose used to connect the tank ship with the underwater pipe line is 12 in. in diameter and consists of eight 25-ft sections bolted together. Hose of this size has become virtually a standard and is probably the largest that can be handled with normal ship's equipment. The hose sections shown

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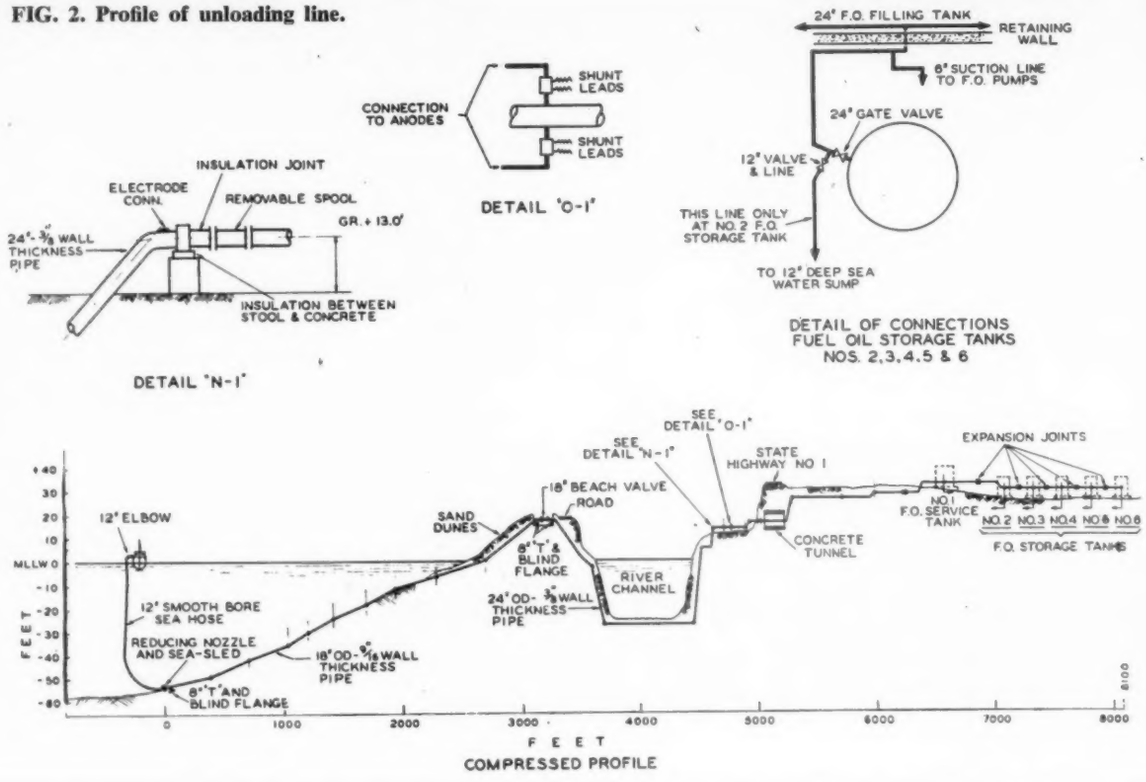
S. P. Johnson E. A. Salo

**S. P. Johnson is technical consultant with Standard Oil Company of California at San Francisco. Educated at Stanford University, he has been consultant on various pipe line projects, including the Trans Arabian Pipe Line and the Trans Mountain Pipe Line. He was a member of the wartime Engineers Committee on Oil Storage for the War and Navy Departments.**

**E. A. Salo is technical engineer with Pacific Gas and Electric Company in San Francisco. He attended New York University, receiving both his B.S. and his masters there. Salo was engineer with Consolidated Edison Company of New York from 1930 to 1940; service engineer with Combustion Engineering, Inc., 1940-45; assistant mechanical engineer for New York State Electric and Gas Corporation, 1945-49, and assumed his present duties in 1949. He is a member of ASME and NSPE.**

†Revised version of paper presented to ASME meeting, Los Angeles, California, 1953.

**FIG. 2. Profile of unloading line.**




on Fig. 4 are fabricated on A.P.I. nipples, which are first welded to standard 300-lb flanges. The hose was fabricated from neoprene for oil resistance, with six plies of heavy hose duck reinforcing. Two braided steel wires, wound spirally opposite are incorporated in the carcass, and the outer surface is provided with an abrasion resistant neoprene cover. Closely wrapped galvanized spring binding wire is used to clamp the hose to the nipples. The metal ends of the hose are electrically bonded. This is a practice that was developed to prevent electrostatic potentials in dock hose discharging dry products, but it serves to insure cathodic protection to the nipples and flanges.

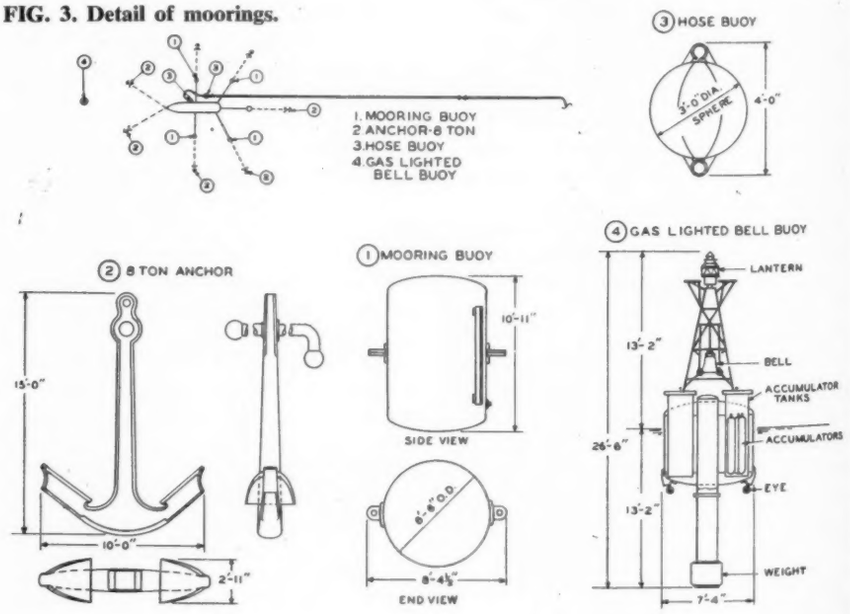
## Moorings

The mooring facilities at an offshore terminal or open roadstead, such as that at Moss Landing, are of paramount importance. Aside from a matter of safety, a good layout insures that comparatively little time will be taken up in mooring and unmooring, and most of the ship's time can be utilized in necessary pumping. The facilities at Moss Landing are the result of long experience on the California Coast and have, as a matter of fact, been copied elsewhere in quieter waters.

The ship is moored to five permanent 8-ton steel anchors, three at the stern and two amidships. The ship's anchors hold the bow. The mooring is laid out so that the ship faces the prevailing west wind. These details are shown on Fig. 3. The submarine line is brought out to a depth of 50 ft, which provides a safe margin for the 33-ft maximum draft of fully loaded tank ships. For a permanent installation, heavy steel anchors without movable parts were considered preferable to the more efficient anchors now carried on Navy ships. The anchors are connected by stud link chains to buoys to which the tank ships moor. The buoys are provided with so-called pelican hooks which can be released by a jerk line. The pelican hook is a safety precaution, more important now that almost all ships use wire lines for mooring.

As shown on Fig. 3, the mooring is marked by a lighted bell buoy located due west of the unloading line terminal. In addition to making it easier for the ship to sight the mooring this buoy warns the local fishing fleet of the presence of the mooring buoys that can damage those smaller vessels. The lighted buoy is classed as a private aid

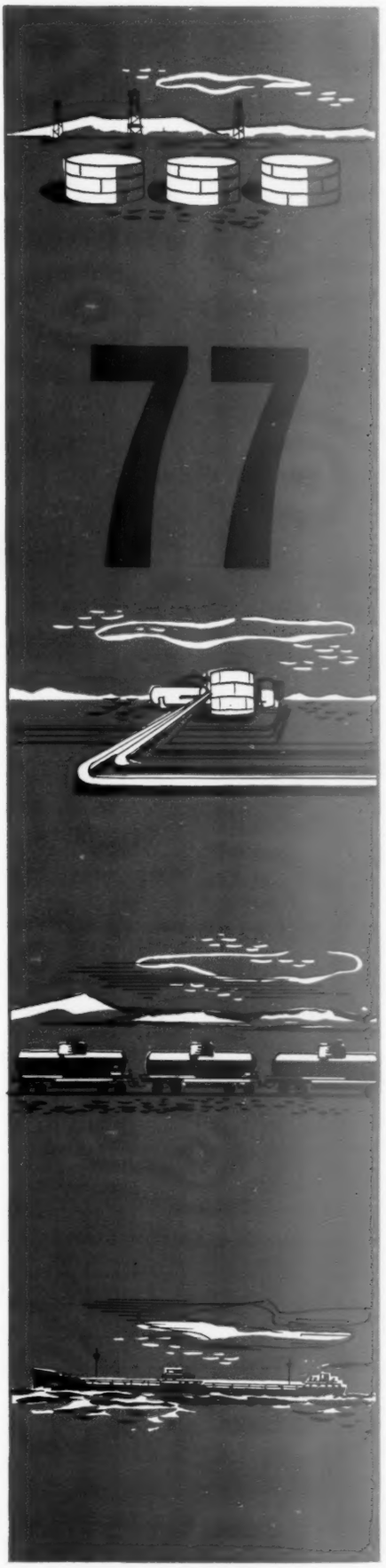
**FIG. 3. Detail of moorings.**



# PREVENT CORROSION and RUST FORMATION

## IN STORAGE TANKS, PRODUCTS PIPE LINES AND TANKERS WITH

# KONTOL 77



*Kontol 77 prevents corrosion and rust formation in facilities for handling finished products. It is an oil-soluble organic inhibitor, and can be used effectively in the prevention of corrosion in products lines, tankers and storage tanks.*

*Extensive research and commercial usage have proved Kontol 77 to be an effective preventive of rusting caused by the presence of oxygen in finished petroleum products.*

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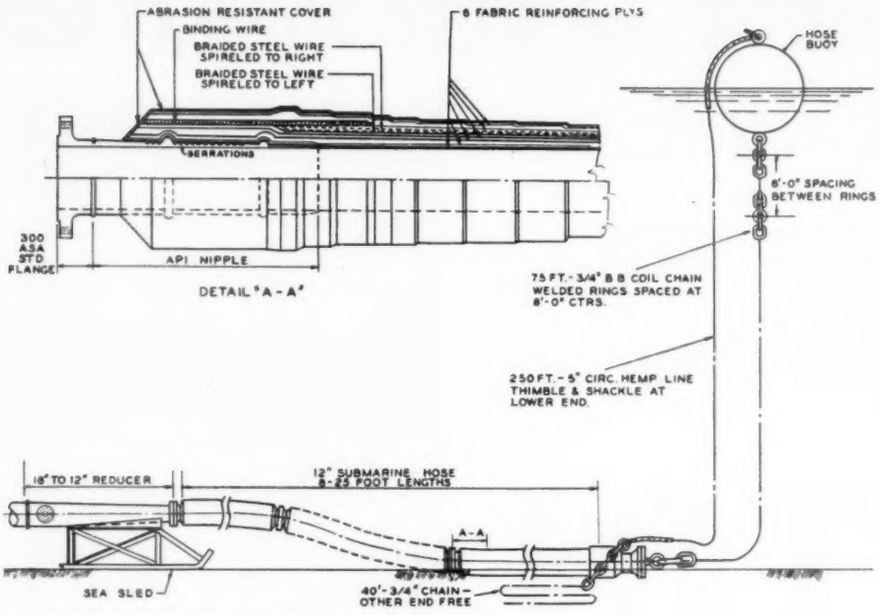
ABRASION RESISTANT COVER
BINDING WIRE
BRAIDED STEEL WIRE SPIRELED TO RIGHT
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6 FABRIC REINFORCING PLYS
SERRATIONS
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DETAIL "A-A"
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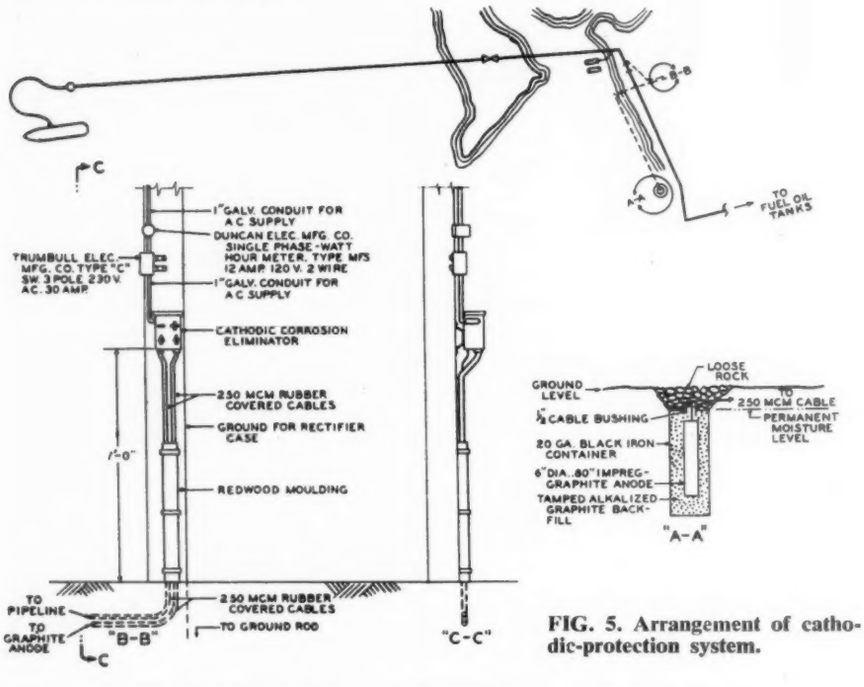
12" SUBMARINE HOSE 8-25 FOOT LENGTHS
A-A
SEA SLED
40'-3/4" CHAIN - OTHER END FREE

**FIG. 4. Submarine hose details.**


B-B
C
TO FUEL OIL TANKS
1" GALV. CONDUIT FOR A.C. SUPPLY
DUNCAN ELEC. MFG. CO. SINGLE PHASE-WATT HOUR METER, TYPE MF3 12 AMP. 120 V. 2 WIRE
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CATHODIC CORROSION ELIMINATOR
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GROUND FOR RECTIFIER CASE
1'-0"
REDWOOD MOULDING
TO PIPELINE
TO GRAPHITE ANODE
250 MCM RUBBER COVERED CABLES
TO GROUND ROD
"B-B"
"C-C"
GROUND LEVEL
LOOSE ROCK
½" CABLE BUSHING
250 MCM CABLE TO PERMANENT MOISTURE LEVEL
20 GA. BLACK IRON CONTAINER
6" DIA. .80" IMPREG-GRAPHITE ANODE
TAMPED ALKALIZED GRAPHITE BACK-FILL
"A-A"

**FIG. 5. Arrangement of cathodic-protection system.**

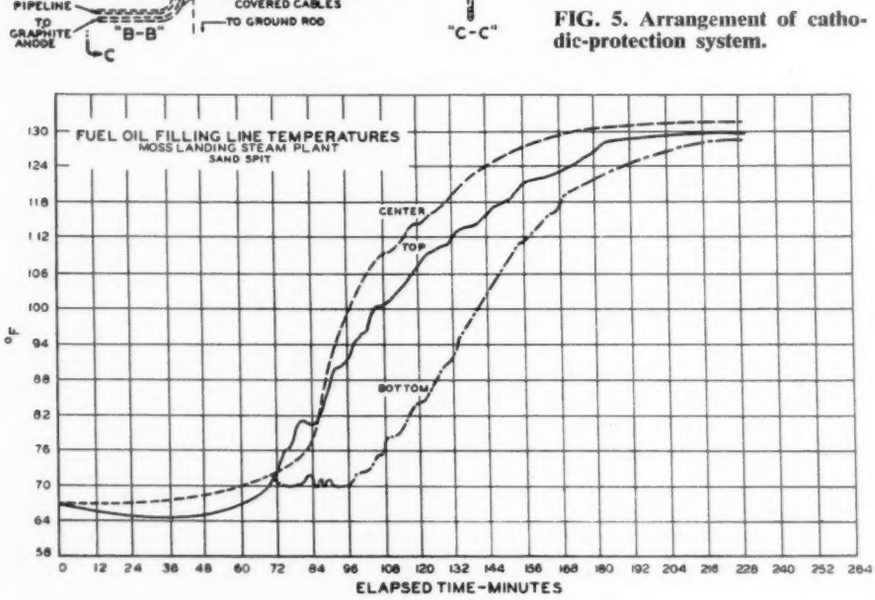


**FIG. 6. Graph of fuel-oil temperatures at beach valve.**

to navigation, and conforms to Coast Guard standards.

### Cathodic Protection

Although the line has a heavy coating that gives excellent protection against corrosion where intact, cathodic protection is used in addition. It provides a virtually complete guarantee against corrosion at local breaks in the coating and the cost is trivial in comparison to the expense of the inspections, tests, and local repairs that it eliminates.

The high electrical resistivity of the coating permits the use of a low current from a small permanent carbon anode instead of a current of a hundred or more amperes from perhaps two large underwater anodes of scrap pipe. Such anodes are not only consumed by normal electrolysis but are subject to local failure and have even washed ashore in heavy weather elsewhere on the California Coast where it was necessary to use them in protecting bare pipe.

As shown in Fig. 2, the protected pipe under the ocean and river channel is separated from the tank line and connections by an insulating flange, near which the current from the rectifier is applied through a 250-MCM cable.

The anode, shown on Fig. 5 consists of a 6-in diameter carbon rod, 80-in. long, buried below the level of permanent moisture in a bed of graphite mixture. A can of 18-gage black iron, 20-in. diameter, was used as a form to hold the mixture and keep the rod centered while it was tamped in place. A ½-in. cable bushing on top of the can protects the cable connection during construction. The excavation over the assembly is backfilled to ground level with loose rock. The can, of course, corrodes out fairly quickly leaving the graphite mixture in direct contact with the earth.

Power is provided by an 8-v, 8-amp, pole-mounted rectifier as illustrated on Fig. 5. The current capacity of the rectifier is considerably higher than the anticipated needs, but is the smallest rating commonly used. The effectiveness of the cathodic protection system in preventing corrosion is appraised by periodically testing a bare steel corrosion coupon, electrically bonded to the pipe and buried alongside it, for weight loss. An unbonded coupon in the same environment serves as a control. The rectifier is now operating at a current of three amperes and the corrosion coupons indicate adequate protection at this level.

The corrosion coupons are installed fairly close to the rectifier rather than at the offshore end of the pipe line. Experience with other similarly coated

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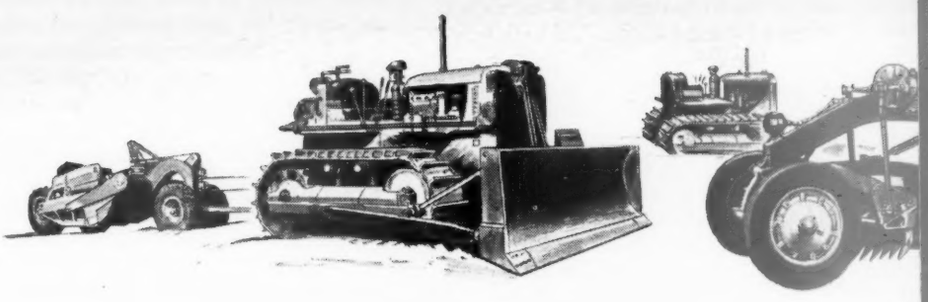

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lines has established that voltage attenuation is negligible under comparable conditions of length, diameter, and wall thickness, and the coupons as installed may therefore be taken as representative of the effect of the cathodic protection system upon the entire line.

### Hydraulic Design of Line

The selection of the best size for an unloading line hinges on a balance between the cost of the facilities and the value of the ships' time in port. The discharge capacity and pressure of the pumps on the ships that will probably call at the port must also be considered in the design basis.

Where ordinary crude oil or products of moderate viscosity are concerned, the problem is a simple one, but in this case where heavy bunker fuel of 175 Furol viscosity, or perhaps more, was to be delivered through two-thirds of a mile of line laid under cold sea water, the matter was not so easy and in fact required the estimation of heat losses and pipe friction under conditions where there was no directly comparable experience.

Experience in pumping viscous oils through lines that lose heat rapidly to the surroundings has shown that a relatively small difference in the pipe diameter or length can make a wholly disproportionate difference in the time necessary to displace the plug of cold oil that chills and congeals in the line between deliveries with warm oil. In fact, there is a limiting set of conditions for such lines where starting from cold is impossible unless the line is left full of oil of low viscosity between pumpings, and indeed, many lines buried in the ground have to be preheated by pumping hot light stock before the viscous crude or fuel can be started without the hazard of plugging.

There was little fear that a line of the size selected for Moss Landing could not be readily started when filled with cold viscous oil, but there was considerable doubt about the necessary time to establish full flow. There was real apprehension that a line of appreciably smaller size would not only be uneconomical but might prove impossible to start unless left full of light oil. Experience now indicates the probability that a line as small as 12-in. could be started, although full flow would not be reached for several hours.

**TABLE 1. Limiting viscosities.**

| Temperature F | Maximum kinematic viscosity, centistokes |
|---|---|
| 45 | 40,700 |
| 50 | 30,500 |
| 55 | 20,500 |
| 60 | 13,800 |
| 70 | 6,800 |
| 80 | 3,300 |
| 90 | 2,000 |
| 100 | 1,180 |
| 105 | 930 |
| 110 | 730 |
| 115 | 570 |
| 120 | 460 |
| 125 | 375 |
| 130 | 305 |
| 135 | 252 |
| 140 | 210 |

The initial pumping conditions with everything cold and all the flow in the laminar range and the final conditions of the line in full operation could both be established with fair certainty, but the problem of starting was to determine how long it would take to get from one condition to the other or, in fact, at the worst, whether it would be possible to get from one condition to the other in any reasonable time.

In estimating the probable time of displacement, it was necessary to estimate the average viscosity, and this depended on the temperature and, hence, the rate of heat loss. The information available was sketchy and conflicting. Heat transfer in small tubes of moderate length has been investigated rather well, but a little thought indicated that such information was not applicable to a large pipe of considerable length where unquestionably free thermal convection would turn the contents of the line over fairly rapidly.

Information was available on the performance of an 18-in. buried pipe line in Venezuela which handled oil at 7500 centistokes. This line showed a surprisingly high coefficient of heat loss, about 0.5 Btu per square foot per hour — degree F. Since the transfer between pipe and ground is known to have this general order of magnitude, there is not much left to be ascribed to thermal resistance between the oil and the pipe. The following estimate was made, however:

| | Heat-transfer coeff. based on external pipe surface | Thermal resistance |
|---|---|---|
| Oil to pipe wall, (approximate) | 3 | 0.33 |
| ⅔ inch of steel | 4800 | — |
| ⅔ inch of Somastic pipe coating | 17.7 | 0.13 |
| Coating to sea water—(pipe probably half-buried in sand) | 15 | 0.07 |
| Over-all | 1.9 | 0.53 |

Preliminary calculations showed that even with complete mixture throughout the cross-section of the pipe, (which might be approached as a result of thermal circulation) with the estimated initial delivery rate of 300 bbl an hour, and with a heat transfer coefficient of 1.9, the mean temperature of the stream at the tanks would still be more than 10 deg above the minimum estimated ground and sea temperature of 50 deg. Even this residual temperature would reduce the viscosity of the displacement oil to about one-third that of the cold oil in the line and would hence correspond to a pumping rate of some 900 bbl per hour, if it existed throughout the whole line. Of course, by the time the nose of hot oil arrived at the beach, most of the line would be much warmer, and the flow rate would consequently be much greater.

**TABLE 2. Estimated comparison of various size lines.**

Sea line 3600 ft; shore line 4000 ft (net for pumping)
200 Furol viscosity oil at 122 F, 20,500 centistrokes at 55 F
Hose 12 inch, 200 ft
Sea water 55 F

| Line OD | 14″ | 16″ | 18″ | 18 & 24″ |
|---|---|---|---|---|
| Approx. vol bbl | 1300 | 1680 | 2150 | 3100 |
| Starting rate bph | 85 | 145 | 190 | 340 |
| Final rate bph[1] | 4000 | 5600 | 7300 | 9200 |
| Displ. time hr | 8.6 | 5.9 | 4.4 | 2.2 |
| Pumping time hr at max. rate | 27.2 | 19.3 | 14.7 | 11.4 |
| Allowance for stripping | 1.0 | 1.0 | 1.0 | 1.0 |
| Total pumping time (110,000 bbl) | 36.8 | 26.2 | 20.1 | 14.4 |
| Approx. steel tonnage[2] | 267 | 306 | 365 | 435 |
| Total comparative cost[3] | $133,000 | 153,000 | 183,000 | 212,000 |
| Annual cost of shipping time | $66,000 | 47,000 | 36,000 | 27,000 |
| Years for saving in delay to pay for next larger line | 1.0 | 2.7 | 3.1 | Note[4] |

Notes: [1] This is based on a constant friction factor of .04. The flow for the most part will lie in or near the transition zone between laminar and turbulent except during the displacement period when the flow is laminar.
[2] In the pipe lines only.
[3] At $500 per short ton; estimated net cost of steel and directly concomitant materials in place.
[4] Considering 12 deliveries a year, at a nominal ship's value of $150 an hour; this will not provide much, if any, profit for the carrier.
[5] Larger facilities not estimated; would be doubtful because of limited pumping capacity for viscous oil on many tankers.

A step-by-step process would in general be required to estimate the starting time, but after making a few figures, it became evident that since the viscosity changes so rapidly with temperature, virtually all of the resistance would reside in the undisplaced portion and within the possible accuracy of any calculation, the friction loss in the displaced portion could be neglected. This assumption permits the displacement time for the two sections to be expressed by two equations.

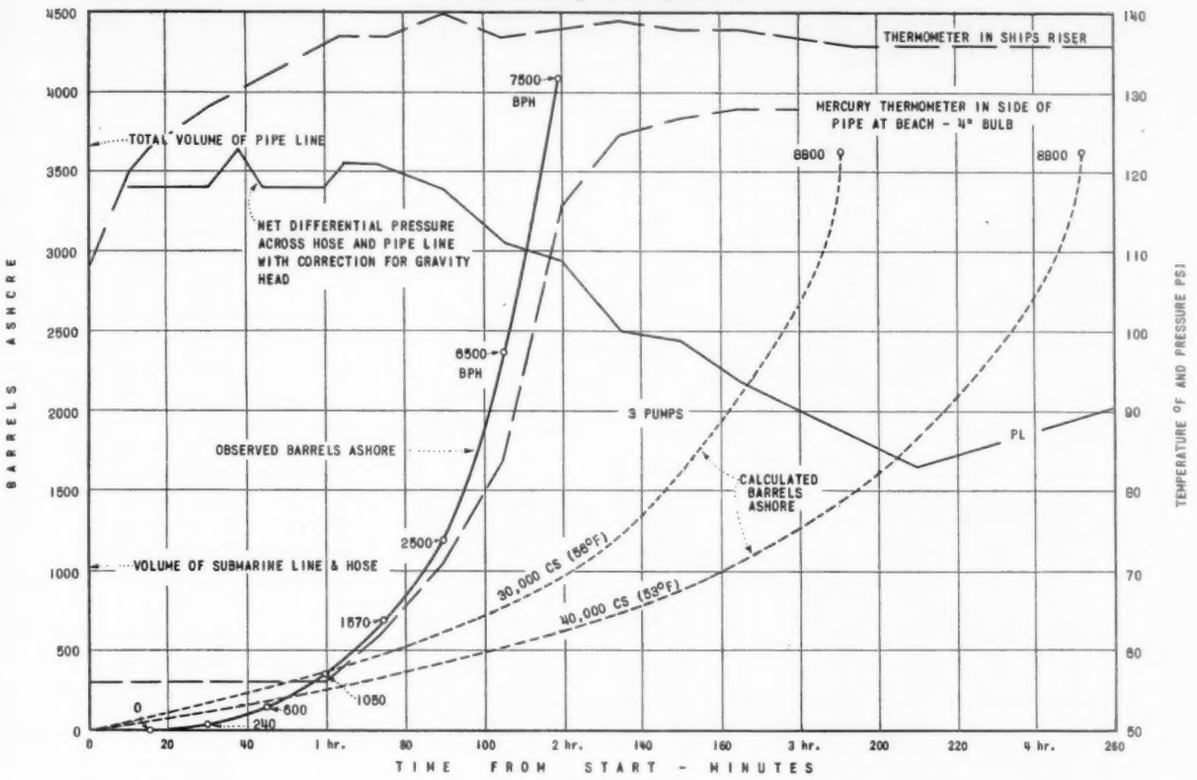
### Displacement Time

In making this estimate of displacement time (Table 2) the principle of volumetric displacement was assumed. That is, it was assumed that any portion of the pipe line would be displaced with warm oil from the ship when, and only when, a quantity of oil equal to the volume of the section had been pumped. Of course, it was known that this assumption could not actually be fulfilled.

During the starting period, the flow in both the warm and cold sections of the line would be laminar, and with laminar flow at constant temperature, the velocity in the center of the pipe is twice the mean velocity. Thus, it was evident that the nose of warm oil would travel through the center of the pipe at least twice as fast as the average speed of the stream, and as a matter of fact, it was believed that it would go ahead at a somewhat faster rate.

Thermal circulation was certainly to be expected, and there appeared to be no way to predict the actual flow

**FIG. 7. Graphical log of test.**




pattern. All that was really assumed was that the simple but admittedly artificial pattern of volumetric displacement with resistance equal to that calculated on the basis of normal laminar flow in the cold section would not give a better result than the actual result with whatever the flow pattern might turn out to be.

Once the line was heated up and in full operation, the flow would be turbulent, and the thermal resistance between the oil and pipe would presumably become quite small. This would leave an over-all heat transfer coefficient of about 5.0, which was compatible with previous experiences with under-water lines, and later verified by the operation of this line although only on an order-of-magnitude basis.

At the expected final flow rate of 8000 to 10,000 bbl per hour, the temperature drop would be quite small, even with this high coefficient, and normal turbulent flow was assumed. The maximum friction factor normally experienced with turbulent flow in smooth pipes is about .042, and is experienced at a Reynolds number of about 3000 at the upper boundary of the transition zone between laminar and turbulent flow. In handling flow problems in this region, it has been quite customary to use a constant friction factor of 0.04, since the viscosity can seldom be known with certainty and this value gives a generally "safe" value at any Reynolds number between about 1600 and 4500. Normally, the actual friction factor will be a little less, and it will never be appreciably more. The figures shown on Table 2 were estimated by the principle of volumetric displacement and with a constant friction factor of .04 after full flow was established.

The original calculations were based on 90 psi net pressure difference across the submarine line and hose. This was presumed to allow a generous margin for static head and probable average pressure somewhat less than the rated working pressure of 125 psi on the hose, but as it turned out the allowance was about right for the larger ships and not enough for ships of the T-2 type.

**TABLE 3. Fuel and unloading data.**

| | 200 Viscosity | | | 170 Viscosity | | |
|---|---|---|---|---|---|---|
| | Max. | Min. | Mean | Max. | Min. | Mean |
| Vis. SSF @ 122.. | 200 | 193 | 196 | 180 | 165 | 170 |
| Gravity deg. API. | 8.9 | 8.0 | 8.45 | 9.65 | 8.5 | 9.0 |
| Kinematic vis centistokes.... | 426 | 411 | 417 | 383 | 351 | 362 |
| Specific gravity... | 1.008 | 1.014 | 1.011 | 1.002 | 1.011 | 1.007 |
| Pour point F..... | 35 | 25 | 30 | 35 | 25 | 30 |
| Sludge and water percent..... | 0.50 | 0.20 | 0.29 | 1.20 | 0.06 | 0.49 |
| Ships R. C. Stoner, J. H. Tuttle | | | | | | |
| Discharge time hr | 18.08 | 15.25 | 16.56 | 18.50 | 13.25 | 15.56 |
| Average flow bbl per hr..... | 7295 | 6095 | 6665 | 8335 | 5915 | 7090 |
| Starting period hr | | | 0.79 | | | 0.56 |
| T-2 Ships | | | | | | |
| Discharge time hr | 19.42 | 15.92 | 17.67 | — | — | — |
| Average flow bbl per hr..... | 6355 | 4850 | 5540 | — | — | — |
| Starting period hr | | | 1.05 | | | |

Pumping equipment–R. C. Stoner and J. H. Tuttle
4-Turbine driven main cargo pumps (3 ordinarily used) Vertical centrifugal. Rated 6785 bbl per hr each on water.
2-Vertical duplex stripping pumps, 16" x 14" x 12" rated 1731 bbl per hr each on water.

Pumping equipment–T-2 type vessels
3-Motor driven main cargo pumps.
Horizontal centrifugal. Rated 2855 bbl per hr each on water.
3-Vertical duplex stripping pumps, 14" x 14" x 12" rated 1731 bbl per hr each on water.

| | |
|---|---|
| Average time to moor, connect hose, on moor... | 3.05 hr |
| Average time to discharge cargo..... | 16.34 hr |
| Average time miscellaneous delays ..... | 1.40 hr |
| Average time at moorings..... | 20.79 hr |

## Estimates vs. Actual Performance

Table 3, "Fuel and Unloading Data," shows the average operating results obtained from unloading 23 tank ships at Moss Landing. Examination of this table and the data back of it showed that, while the apparent starting period of the line was shorter than the prediction indicated in Table 2, the over-all flow rate was somewhat poorer. Furthermore, there was a definite indication that the maximum flow rate was less for fuel of 200 viscosity than that for 170 viscosity. In order to get more accurate information than that provided by the operating records, a test was run on April 8 and 9, 1953.

During this test, the pressures and temperatures were taken with care, and the shore gages were taken as accurately as possible, and at exact 15 minute intervals during the starting period and for some time after full flow was established. Samples of the oil that lay in the line at the start of the unloading and of the oil carried by the ship were tested for viscosity in the laboratory. The displacement time and flow rate under full-flow conditions were then recalculated by the method used in preparing Table 2, but with the actual figures of viscosity, temperature, static head, length of line to the particular tank, and average pressure at the ship's hose connection.

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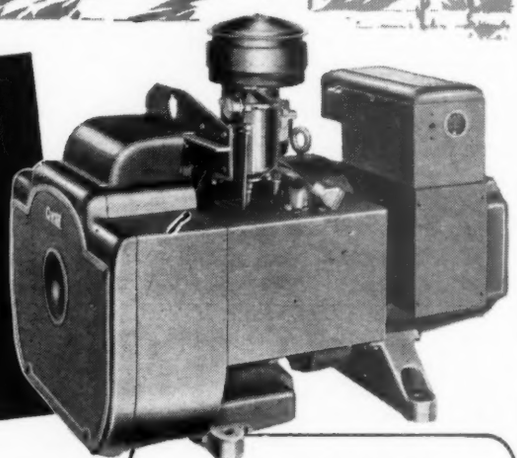

**Microwave transmission** is only as dependable as each of its relay links. If one repeater station cannot operate, messages do not get through.

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- **COMPACT**—Take less than one cubic yard of space. Easier to install. Connection box provided for quick hook-up.
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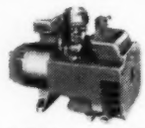
**3,500 watts A.C.**
2-cyl. air-cooled



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Water-cooled

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### Viscosity

The viscosity of the oil in the line was approximately 200 SSF at 122 F and that of the oil discharged by the ship was approximately 175. The slope of the viscosity-temperature relationship was greater than indicated by Table 1 and the viscosity of the cold oil in the line before starting was approximately 40,000 centistokes at 53 F and 30,000 centistokes at 56 F. The viscosity of the cold oil in the line was believed to lie between these limits as a result of temperature measurements taken during the test, although the temperature of the sea water at 30 ft depth on the night in question was 50 F.

The result of the tests are summarized in Fig. 7. The two dotted curves marked 30,000 and 40,000 represent the calculated displacement characteristics of the line as determined by the volumetric displacement method with the friction in the warm section neglected as explained previously. The solid line shows the actual barrels ashore by tank gage. Examination of these curves and the tabulated test results leads to the following conclusions.

1. *The line reaches maximum pumping capacity in about two hours instead of three or four hours as would be calculated by the method of volumetric displacement.*
2. *In spite of this, the initial flow rate when pressure was first put on the line was very much less than calculated. The calculated initial flow rate is in the vicinity of 300 bbl per hour (depending on the assumed viscosity and the time to displace the hose which contributes substantially to the effective length of the line but holds only 30 bbl) indicating that 75 bbl would be gaged ashore in the first 15 min. There was no measurable quantity delivered ashore in the first 15 min, and only 26 bbl in the first 30 min. This indicates that the oil has some thixotropic properties and that time is required to start it moving, even though the temperature is well above the laboratory pour point.*
3. *In spite of the fact that the volumetric displacement method does not result in an accurate prediction of the starting time, full flow was achieved at approximately the time when the total volume of the pipe line (3700 bbl) had been pumped ashore.*
4. *The flow rate after steady conditions were established was definitely poorer than calculated. It averaged 7740 bph for the 9½ hours of maximum steady delivery rate instead of the 8940 bph that would be calculated*

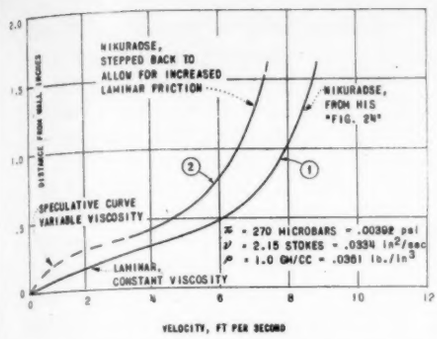

NIKURADSE, STEPPED BACK TO ALLOW FOR INCREASED LAMINAR FRICTION
NIKURADSE, FROM HIS "FIG. 24"
SPECULATIVE CURVE VARIABLE VISCOSITY
LAMINAR, CONSTANT VISCOSITY
DISTANCE FROM WALL, INCHES
VELOCITY, FT PER SECOND

**FIG. 8. Velocity distributions in pipe line.**

*with a friction factor of .04, or the 9200 bph that would be calculated with a friction factor of .038 corresponding to the smooth pipe law for flow at constant viscosity. The indicated friction factor was .053 which is almost 40 per cent above the smooth pipe value for constant viscosity.*

### Temperature Drops

The over-all temperature drop through the pipe line could unfortunately not be determined from the test with any accuracy. On account of the difficulty of getting a true average value, the four sets of thermometers at the beach, at an intermediate point at the tunnel, and at two points near the tankage showed considerable disparity. The over-all temperature drop, however, was certainly not more than 5 F and the mean temperature therefore could not have been more than two or three degrees from that assumed in calculation. This could not affect the mean flowing viscosity to any significant extent.

### Reason for Excessive Friction

Since the excessive friction cannot be due to mean temperature lower than assumed the explanation for it must lie in higher shear forces at the pipe wall than those to be calculated from the mean viscosity and the normal velocity distribution for turbulent flow. The normal or Karman-Nikuradse velocity distribution near the wall of the pipe is shown in Fig. 8, (Curve 1). The total flow as determined by integrating this velocity distribution over the entire pipe area of course comes out to 9200 bbl per hour which is too great as previously indicated.

Curve 2 on this figure shows a velocity distribution of the Karman-Nikuradse form drawn back by the amount necessary to agree with the observed flow. Near the wall, a speculative form has been dashed in to show how excess friction might develop as a result of non-uniform viscosity in the laminar layer adjacent to the wall. Curve 2 of course, rests on the assumption that the velocity distribution inside the turbulent core is substantially normal and is effected only by the viscosity in the core and by the shear stress or tractive force at the transition zone between the turbulent core and the laminar layer along the wall.

As drawn the curve shows the total thickness of the laminar layer about the same as that which would obtain with uniform viscosity. This is doubtful; probably the total thickness of the laminar layer is somewhat increased by the additional viscosity of the portion next to the wall.

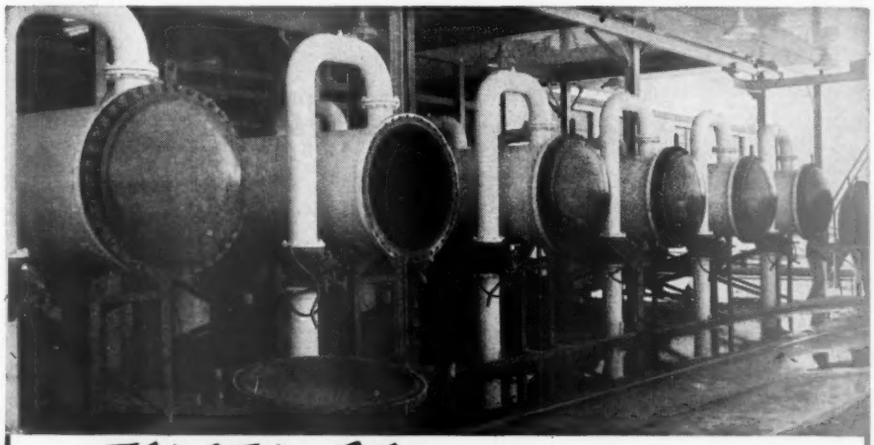
After steady flow is established, there is an axial temperature gradient in the laminar layer adjacent to the wall as well as a radial gradient. Calculation of such gradients has seemed well beyond the scope of this paper, but several checks have been made to determine that the total amout of heat lost by the oil in its transit from the ship to the tankage is sufficient and has the correct order of magnitude to chill half the laminar layer by some 20 F, which is all that is needed to explain the observed friction. It has also been noted that the thermal resistance of a layer of oil having a quarter of the presumed thickness of the laminar layer is about what it takes to explain the total heat loss when added to the other thermal resistances.

### Performance of Ship's Pumps

The over-all performance of the Moss Landing line is determined not only by the characteristics of the line itself, but also by the pumps on the ship. The allowable working pressure on the hose at Moss Landing is considered to be 125 psi, which provides a very high factor of safety since the hose is tested at 250 psi. Although the pumps on the ship were able to put 125 psi on the hose at the start, they were unable to maintain it at the maximum flow rate, despite the fact that they have very much higher capacity rating on stock of lower viscosity.

During the April tests, the average pressure maintained at the ship's manifold was 102 psi, and although detailed consideration of the performance of the centrifugal pumps on the ship is beyond the scope of this paper, it may be noted that this is somewhat below the performance that would be calculated by the methods usually employed in estimating performance of centrifugal pumps when handling viscous material.

The "R. C. Stoner" which delivered the oil during the test has turbine-driven pumps operated at 275 bhp each. When confronted with a power demand beyond their design rating, these pumps simply slow down, as they indeed did during the test. Constant

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speed pumps of limited horsepower such as those on vessels of the T-2 type, however, are affected to a greater extent since they have to be throttled if motors become badly over-loaded.

Reference to Table 2 shows an average flow rate of only about 5000 bph to T-2 type ships, and since the pumps have to be throttled to prevent motor overload, this is determined entirely by the characteristics of the pumps, rather than the maximum capacity of the line, whereas in the case of turbine-driven pumps, the rate of discharge is determined by a combination of the two.

### Radio Communication

In order to co-ordinate operations between ship and shore, the use of frequency-modulated short-wave radio was investigated and found to be the most practical. A 15-w base station is licensed by the Federal Communications Commission for use on a frequency of 158.25 megacycles. This channel is one of four assigned to the Pacific Gas and Electric Company.

The fixed plant equipment consists of a 15-w base station, with the call letters KMA 637. A 12-w mobile unit installed in the plant carry-all, one 15-w a-c-powered portable set for plug-in-operations on board the tankship, and four pack-set battery-operated sets for standby service also are provided. All of these units are operated under the base-station license. A sufficient number of the plant personnel hold 2nd-class radio-telephone operator's licenses, with the result that radio communication is permissible at all times.

Throughout the unloading operation, communication is through the base station. The relaying of messages between the mobile crew and the ship through the plant station causes no delay but actually improves co-ordination. As the plant supervisors keep in touch with all of the various operations through the radio log, emergency conditions can be recognized and dealt with expeditiously. If during unloading operations, radio communication fails, emergency whistle signals by the tanker may be used.

### Operating Procedure

The unloading operation begins when the first contact between ship and shore is made by whistle signals, when the ship calls for the mooring launch and the mooring master. When the ship has dropped its bow anchors in position, the launch makes the ship's lines fast to the breast and stern-mooring buoys. By adjusting the lines, the ship is given a suitable westward heading close to the hose-maker buoy. The hose is hoisted aboard and connection made to the pump manifold.

Care is taken to prevent an oil spill when the submarine hose blank is removed. At first the transfer pumps on shore were used to establish a vacuum on the loading line, but it soon was found that the cooling of the oil in the line between shipments resulted in a vacuum as a result of the oil shrinkage. When the plant radio operator gets the message that the hose connection is completed he directs the party at the beach to open the valve. When word gets back that the beach valve is open, and that the proper valves to storage are open, the ship is advised that pumping can start.

Hourly readings of oil flow and temperature are taken. A continuous drip sample is collected for laboratory analyses. The storage tank is gaged before and after the unloading operation, and tank-strapping data are used to calculate the volume delivered, which is corrected for temperature variation.

When the ship tanks are empty and stripped the plant is advised. Originally a transfer pump was started and used to put a vacuum on the unloading line but the current practice is to blow just enough of the hose out with compressed air to prevent a spill when the hose is disconnected. The mooring launch assists the ship in casting off the mooring lines, the ship's anchors are hoisted, and the operation is over.

### Maintenance

Maintenance of the moorings and of the submarine line is almost entirely on a preventive basis. The service of a derrick barge and towboat are needed for raising the lighted buoy and the other equipment. It has been the practice to leave the submarine line up to the beach valve full of sea water when the delivery of fuel preceding the maintenance operation is made. This makes it possible to remove a section of hose without spilling fuel oil, and also permits hydrostatically testing the line without risking an oil spill.

When the heavy fuel of the shipment preceding overhaul is unloaded, it is followed by sufficient light oil to displace the heavy oil in the line from the ship to the beach valve. This is followed by seawater, which is left in the line. The heavy fuel has been followed immediately by seawater with satisfactory results but the use of the light oil provides the best separation of the water from fuel, and in this way minimizes the amount of water that might be carried into the storage tanks, as well as oil that might be wasted in over-pumping the water charge from the submarine line back into the ship when starting the subsequent unloading operation.

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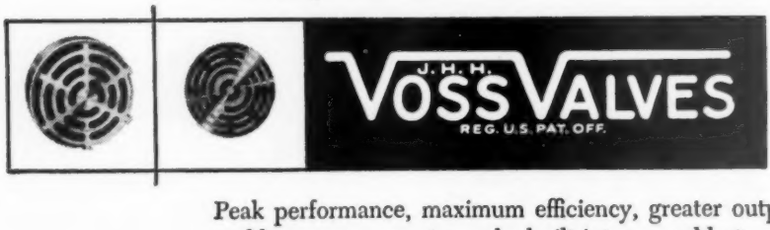


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period is convenient for the contractor and the weather is suitably mild for underwater work. During the overhaul all the mooring buoys are lifted aboard the barge for cleaning and painting. The lighted buoy also is provided with fully recharged acetylene cylinders to replace the six that have been in service for the previous year. Cleaning, painting and adjusting are done as required. The dip sections of the mooring-buoy chains are inspected carefully. A worn section is cut out, but not replaced until the following year. In re-connecting, the shackles are welded closed. The hose buoy also is cleaned and the chain replaced each year. The submarine hose is raised above the water so that three of the 25-ft sections can be inspected for wear. A hydrostatic test at 125 psi is imposed on the submarine line and held long enough to show absence of leaks.

A diver inspects the hose joints that cannot be raised above the water, as well as the underground pipe for the full unburied length. The mooring anchors are either inspected by the diver or raised to the barge deck for inspection. Any changes in the location of the mooring anchors that the mooring master has requested are made at this time.

It is planned to rotate the hose sections when wear develops in order to get the maximum service by equalizing the wear on all the sections. The dip sections of the hose, just as the dip sections of the mooring chains, get the greatest wear. Sufficient hose was provided originally so that a faulty section can be removed without hampering the regular unloading operations. This is equivalent to providing spare hose in service, rather than in dry storage where it would deteriorate at a rate greater than on the sea bottom.

It has been necessary to shift the mooring anchors on two occasions. On the first shipment of fuel it was found that additional scope was needed on the mooring lines. During the first maintenance period the mooring anchors were shifted outward about 75 ft. Again in January of 1953, it was found that the mooring to the south had shifted as a result of unloading during the unusually heavy seas from the south that were experienced during the past winter. From the mooring layout it can be seen that the tank ships lie out to the west, into the prevailing winds. However, during the winter storms the heavy weather was from the south, putting severe strains on the windward breast mooring which shifted enough to interfere with the ease of mooring. As a consequence of this experience it has been decided to jet the mooring anchors to deeper holding. This was done by a diver wielding a jetting pipe supplied with water under pressure.

Some of the shore-line pipe was uncovered by wave action, and it was found necessary to provide protective sheet piling to keep the line buried and secure from storm damage. The piling was driven close to and parallel with the line for a distance sufficient to provide a surf barrier over the full tide range.

The submarine fuel-unloading facility described combines features of reliability, ease of operation, economy of time and manpower that make it worthy of consideration for oil-fuel plants near deep water. Some of the doubtful factors, such as the time to remove cold plugs and the need for recirculation have proved far less onerous than anticipated.

The design used at Moss Landing incorporates margins sufficient to make the unloading time dependent almost entirely on the capacity of the pumps on the ships that so far have delivered oil. The operations corroborate the design estimate that little if anything would be gained by the use of larger diameter piping.

It is the authors' belief that the Moss Landing arrangement can handle fuel oil of viscosity as high as 300 SSF at 122 F without difficulty. * * *

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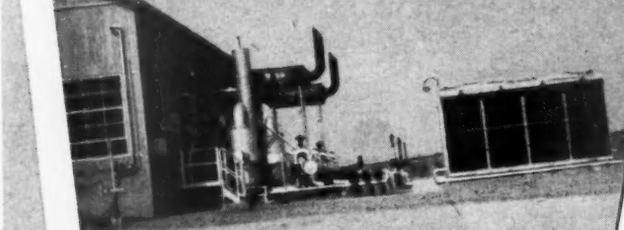

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*Pipe Line Uses of*

# Air-Cooled Heat Exchangers

***Air for cooling has advantage of unlimited supply; types, applications, design considerations, economic factors in selection, and typical installations discussed***

**C. H. HOMER, JR., and S. KOPP**

THE air-cooled heat exchanger may be used economically where heat at a level of 25 F or more above the maximum expected air temperature is to be removed. Its use eliminates such water problems as availability, chemical treatment, corrosion, spray nuisance, freezing hazard, and fouling.

In their early application to industry air-cooled heat exchangers were designed on the basis of natural draft, or to take advantage of the prevailing winds. Their performance was often erratic, due to changes in the direction and velocity of the winds. More than a quarter century ago one of the writers was associated with the design of a natural-draft air-cooled heat exchanger for condensing gasoline and reflux. This unit was essentially a vertical fire-tube boiler with a short stack. For more than 10 years the same refinery in which this unit was installed had used a horizontal shell-and-tube design consisting of a stack of four to six exchangers in series on the shell side. These were stacked so that alternate units were at right angles to each other to take advantage of the prevailing wind.

These first crude heat exchangers demonstrated the feasibility of such equipment, but indicated the necessity for mechanical draft to assure full performance at all times. The past 15 years have been the greatest period of development of air-cooled heat exchangers using mechanical air circulation. Because of this development installations costing $100,000 are quite common, and one plant, completed last year, contains air-cooled heat-exchange equipment costing over $1,000,000.

### Air as a Cooling Medium

Perhaps the most important reason for the development of the air-cooled heat exchanger is the location of the process industries in areas of poor water supply. For example, the vast natural gas fields of Western Texas, Kansas, Oklahoma, and New Mexico have provided the raw materials for an entirely new petrochemical industry, and the industry has found it advantageous to locate near the source of their major raw material. The desert spaces of Arabia and Iran, under which lie vast quantities of petroleum, are another example. Abundant good water for cooling is in short supply in these areas, and the process and petroleum industries have turned to another coolant — air.

Air is abundant, easy to handle, physically stable and noncorrosive except for areas of unusual air contamination. There is no upper limit to which air may be heated; the optimum heat-transfer rate and permissible temperature rise may thus be made the maximum for which it is feasible to design the heat-transfer surfaces of an air-cooled heat exchanger.

Another reason for the trend to air as a cooling medium is the sharp rise in industrial uses of water, causing water supply problems even in areas where water has always been abundant. The water requirements for typical industries are given in Table 1, and point up the problem. As new processes are perfected, industries expand and power demands are increased, the question of the most economical use of water, or its elimination as a coolant, will become more important.

**The Authors**

S. Kopp C. H. Homer, Jr.

C. H. Homer, Jr., is plant manager of Beaumont Iron Works Company, Beaumont, Texas, plant. A graduate of Rice Institute of Technology, he became plant superintendent shortly after joining Beaumont Iron Works Company, before Beaumont became an affiliate of American Locomotive. In 1949 he transferred to the Alco Products plant at Dunkirk, New York, as chief quality control engineer, and became project engineer for air-cooled heat exchangers in 1951. A year later he returned to Beaumont as product manager for heat-transfer equipment, and became plant manager in 1953.

S. Kopp is chief consulting engineer of the Alco Products Plant, American Locomotive, Dunkirk, New York. He received his mechanical engineering degree from New York University, and has been associated with American Locomotive Company since 1928.

**TABLE 1. Water use in typical industries.[1]**

| Products | Lb of Water per lb of product |
|---|---|
| Ammonium sulphate | 750 |
| Butadiene | 1200 |
| Carbon dioxide | 175 |
| Dry ice | 150 |
| Hydrogen | 2500 |
| Lactose | 750 |
| Natural gasoline | 24 |
| Oil refinery (per lb crude) | 60 |
| Public utility (per kw generated | 600 |

### Applications of Exchangers

There has been some use of air-cooled heat exchangers for condensing steam in power plants, the most notable being the portable power plants built during the war.[2] The most frequent use has been for jacket-water, lube-oil and gas coolers for gas- and diesel-engine-driven compressor and pumping installations.

The usual air-cooled heat exchanger in process plants is either the induced- or forced-draft type with the heat transfer surface arranged horizontally. A few units with vertical heat transfer surfaces are used, principally for jacket water and lube-oil cooling.

Both the forced-draft and induced-draft types of air-cooled heat exchangers offer advantages inherent in their design and operating characteristics. The forced-draft type is generally preferred for high-temperature cooling when the discharge air temperature is high enough to damage the fan. The induced-draft type permits discharge of the hot air at maximum velocity so that it is removed from the area, and cannot be picked up again by the fan and recirculated. The hood and fan duct also protect the heat transfer section from solar radiation, rain, hail and freezing weather. This type gives better air distribution over finned-tube sections, and since the sections are closer to the ground, no walk-ways are needed.

Finned tubing constitutes the heat-transfer surface on units used for process work, and in many cases this design is used for jacket-water cooling. This is particularly true when danger of freez-



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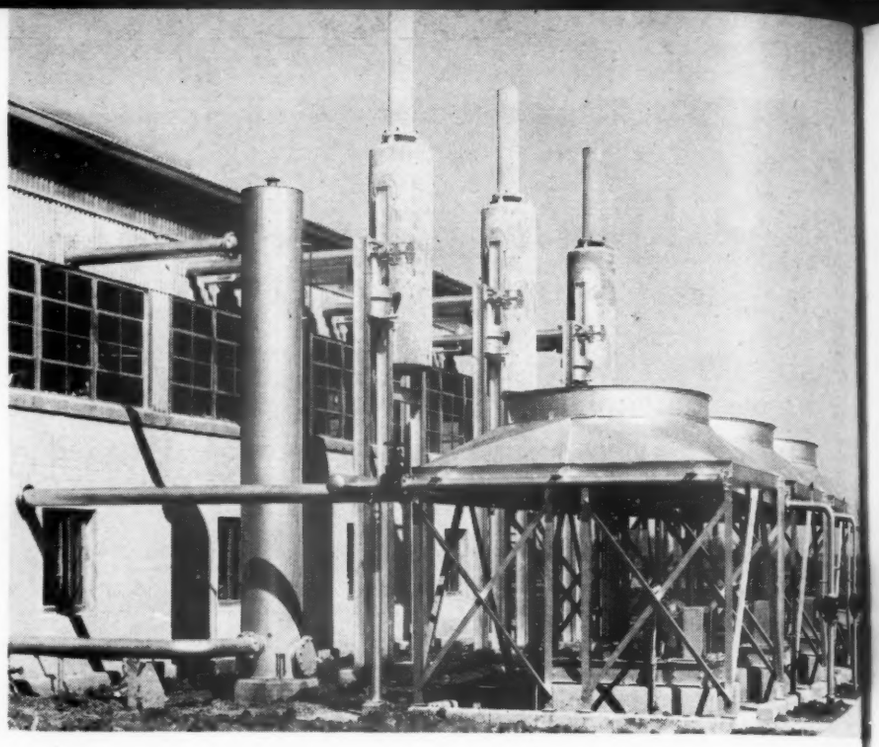


**Air-cooled heat exchangers used on compressor station in Mississippi.**

ing may be a consideration. Radiator construction is used for low-cost jacket-water coolers, and has also been used for lube-oil cooling and steam condensing.

Finned-tube sizes used are ⅝-in. and 1-in. OD with 5 to 11 fins per inch. The fins are ⅜-in. to ⅝-in. high. Normally they are soldered, but they may be welded or brazed to the tube. Tubes with fins tightly wrapped, but not bonded to the tube, are used for jacket-water cooling. One tube manufacturer can furnish a tube with the fin extruded from the tube stock. Finned tubes of differing tube and fin metals are also available.

Structures are generally made up of structural shapes and fabricated steel plate. Some induced-draft units have been mounted directly on a concrete structure, eliminating the steel supporting legs. Masonite panels, instead of steel plate, have been used on some forced-draft installations.

Fans up to six feet in diameter have either two or four blades, while the larger fans have four or more blades. It is common practice today to furnish adjustable-pitch fans, and variable-pitch fans are coming into use. The fans are adjusted to take care of seasonal changes in air temperature, thereby reducing the annual power cost. The average annual power cost will be 50 per cent or less than that computed from the horsepower for design conditions. Variable-pitch fans are controlled by a thermostat, generally installed in the drain line from the equipment. The thermostat automatically adjusts the fan-blade pitch to maintain constant outlet temperature.

### Classifications

To meet industrial requirements, air-cooled heat exchangers are available in a wide variety of design types. The most important are classified as follows:

**Heat-Transfer Surface.**

(a) *Radiator-core type:* Consists of thin copper or copper alloy tubes, usually obround in cross-section, assembled in separated copper leaves which form the extended outside surface. This type of heat-transfer element is usually selected for low-pressure, light-duty applications, not exceeding 50 psi operating pressure.

(b) *Externally-finned tube elements:* Consist of finned condenser tubes, assembled in banks of one to ten rows with the tube ends expanded into fabricated steel or alloy headers. Heat-transfer elements of this type have been furnished for internal pressures up to 5000 psi, and in materials ranging from carbon steel to Type 316 stainless steel, together with copper alloys. Fins may be of tinned copper or aluminum.

**Air-Flow Arrangement:**

(a) *Induced-draft.* The fan is arranged above the heat-transfer surface to discharge the hot gases to the atmosphere at maximum velocity.

(b) *Forced draft.* Fan is below the heat-transfer surface, and blows atmospheric air through the tube bank.

**Fan Drives:**

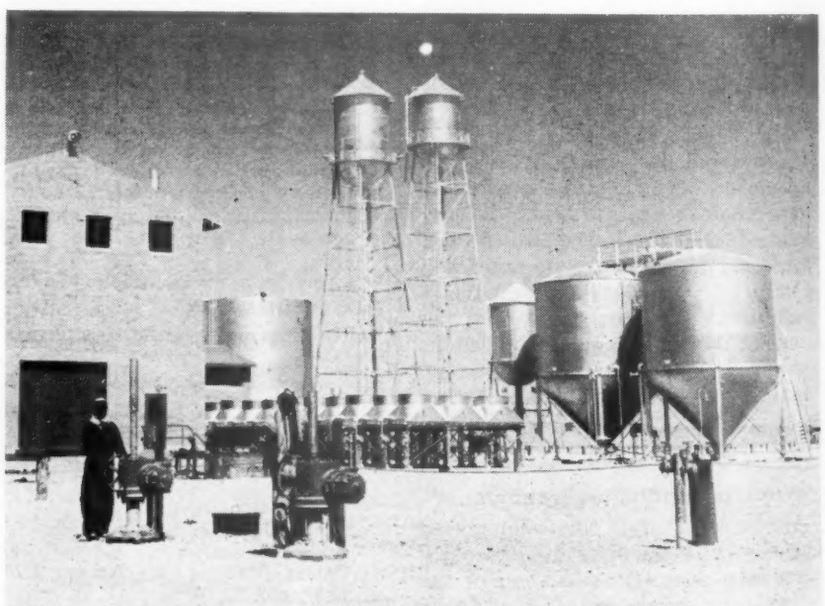
(a) *Direct.* Fan may be directly connected to an electric or hydraulic motor. This is the simplest arrangement, but it is not used for fans more than seven feet in diameter because of the limitations on fan-tip speed.

(b) *Gear.* Larger fans are usually driven through a right-angle gear speed reducer of the worm or bevel type. The drive may be an electric motor, hydraulic motor, turbine or gas engine.

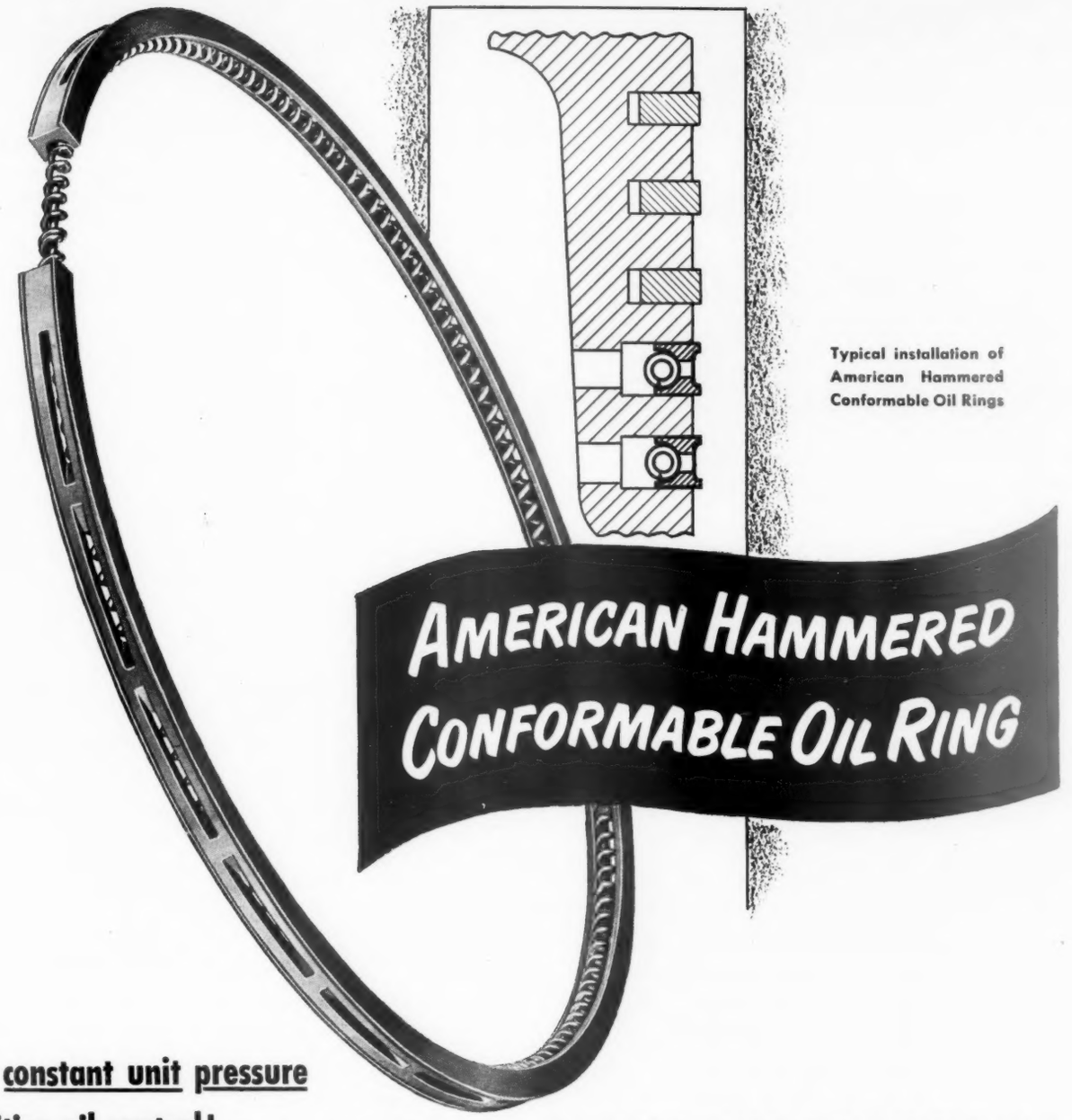
(c) *V-belt.* These drives are preferred over the gear drive for some applications.

**Fans:**

(a) *Adjustable pitch.* Fans of this type may be adjusted, while not running, to move more or less air, as required by variations in ambient air temperature or cooling requirements. As the required horsepower varies with the quantity of air to be moved, savings may be effected by reducing the fan pitch when the air temperature is low, or when process requirements are light.



**Trans-Arabian Pipe Line Company's Badanah pumping station, Saudi Arabia, shows air-cooled heat exchangers at station. Each unit has three fans with number in operation determined by temperature control in water outlet. Units are used to cool water for engine, generator jackets and lube-oil coolers.**



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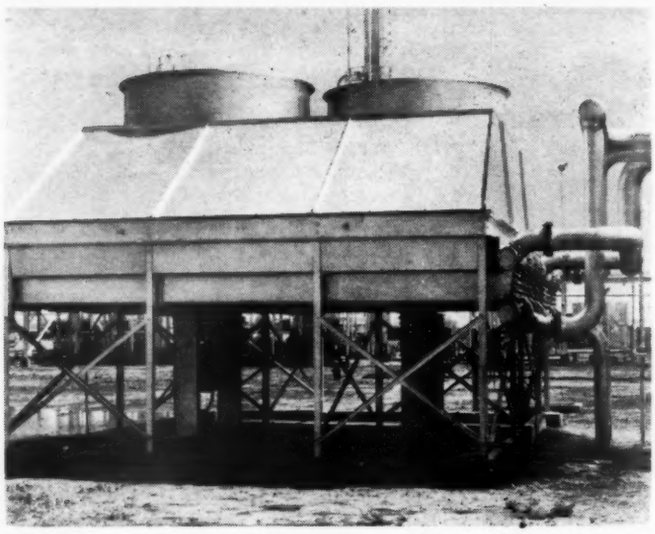


Installation at gas processing plant.

(b) *Controllable pitch.* Fan blades that can be automatically controlled by instruments in the process stream while the fan is running is a more recent feature. This gives the most economical use of fan horsepower, and is usually specified when power costs are high.

**Multiple-Unit Arrangements:**

(a) *One fan.* One cooling element.

(b) *One fan.* Two or more cooling elements.

(c) *Two or three fans.* One cooling element with or without partitions separating several process streams.

(d) *Three or more fans.* Two or more cooling elements.

### Design Considerations

Air-cooled heat exchangers should be designed to cool the hot fluid to the highest final temperature that can be tolerated for short periods. The design air temperature selected should not be exceeded for more than two to three per cent of the hours of the hottest months of the year. Design air temperatures (dry bulb) used are 90 F to 105 F for most installations, although one large pipe line installation was designed for operation with 122 F air.

Most purchasers of air-cooled heat exchangers follow standard practice and supply the manufacturer with all necessary process information for selecting equipment. Air-side process drop or horsepower are generally not specified. It is common practice to limit air-side pressure drop to from 0.4 to 0.5 in. of water. For jacket-water coolers the fan horsepower is generally kept under two per cent of the engine or compressor horsepower.

For purposes of making a preliminary study of fan horsepower requirements the following may be used:

| Service | 1000 Btu per hp |
|---|---|
| Jacket-water coolers | 200-300 |
| Exhaust-steam condensers | 300-500 |
| Hydrocarbon overhead condensers | 200-400 |
| Compressor gas coolers | 300-500 |

$$MTD = \frac{(T_1 - t_2) - (T_2 - t_1)}{\log_e \frac{(T_1 - t_2)}{(T_2 - t_1)}}$$

Where:

$T_1$ = Fluid Inlet Temperature in Degrees F

$T_2$ = Fluid Outlet Temperature in Degrees F

$t_1$ = Air Inlet Temperature in Degrees F

$t_2$ = Air Outlet Temperature in Degrees F

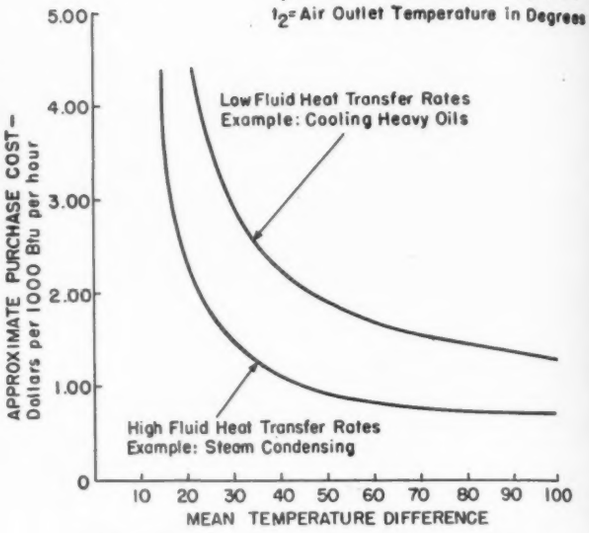



**FIG. 1. Effect of temperature level on purchase price of air-cooled heat exchangers. First cost is shown as function of MTD (mean temperature difference) for two cases where heat transfer characteristics are variable.**

Whereas tube sizes and arrangements have been standardized for the bare-tube shell and tube exchangers that are used in the process industries, this is not the case with finned tubes. Each manufacturer uses finned tubes of his own choice, and as a result published data on finned-tube heat-transfer coefficients should be used with caution. Slight changes in tube arrangement may change heat-transfer and pressure-drop characteristics 20 to 30 per cent. The responsible manufacturer checks each new fin design and tube-fin design or arrangement in a wind tunnel to establish the heat-transfer and pressure-drop characteristics to be used for the design of the exchanger.

Mechanical features to be considered in the design of air-cooled equipment and its installation are:

**Fin-Tube Sections**

(a) Tube material, size and thickness
(b) Fin material, size and shape
(c) Fin bond efficiency
(d) Header type

**Air-Moving Equipment**

(a) Power source
(b) Power transmission to fan
(c) Number and size of fans
(d) Fan material and design

**Structure**

(a) Slab or pier foundation
(b) Induced- or forced-draft design
(c) Structural stability
(d) Ladders, walkways and handrails
(e) Belts, reducing gears, shaft and fan guards

**Controls**

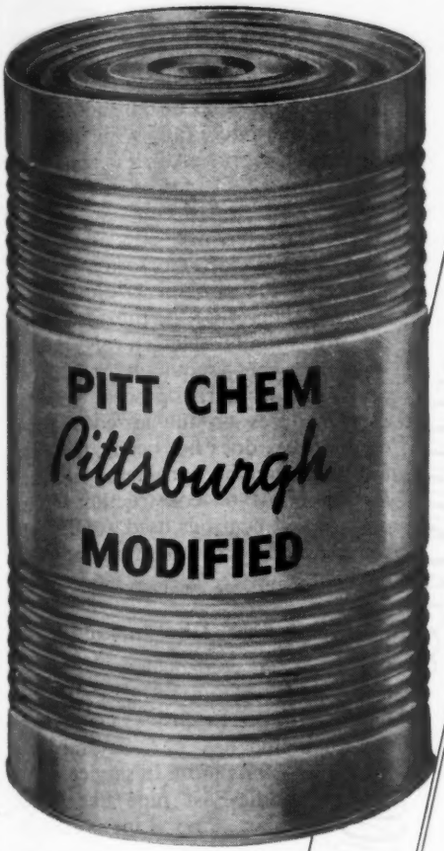
(a) Temperature control instruments
(b) Power control instruments
(c) Louvres, rolling doors
(d) Mixing valves

### Economic Factors

As in almost all equipment, the economic factors in the selection of air-cooled heat exchangers are first cost, operating cost and maintenance cost. Fig. 1 shows the effect of the temperature level on the purchase price of air-cooled heat exchangers. The first cost of the equipment is shown as a function of the mean temperature difference (MTD) between the hot fluid and the air. The MTD may be estimated from the desired inlet and outlet temperatures of the hot fluid, the maximum design ambient air temperature and the discharge air temperature. Appropriate correction factors[3] are applied to the MTD in actual design, but they may be neglected in using the chart.

Surface requirements vary with the heat-transfer characteristics of the fluid being cooled, and the approximate effect of hot-fluid heat-transfer rates on initial cost is also shown in Fig. 1.

A comparison of Fig. 1 with cost data on conventional shell-and-tube coolers and condensers using water as a coolant often indicates an important saving in first cost in favor of the air-type cooler. This is so because the cost of water-cooling equipment must also include accessory water piping, pumps, and disposal or recirculating and cool-




# SPECIFICATIONS

| | |
|---|---|
| Specific gravity, A.S.T.M. D-71 | 1.40-1.50 |
| Softening point, A.S.T.M. D-36 | 190-200°F. |
| Penetration, A.S.T.M. D-5 100 g., 5 sec., 77°F. | 2-6 |
| Ash, A.S.T.M. D-271 | 20-25% |
| Sag test, 7 hrs. | no sag at 140°F. |
| Cold cracking test, 5 hrs. | no cracking or disbonding at 0°F. |
| Peel test | no peel at any temperature from 0° to 140°F. |
| Spark test, (Jeep) | no break through 1/16" coating using 8,000-10,000 volts, low amperage |

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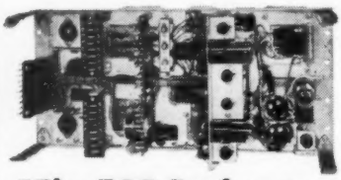

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ing equipment. Air, on the other hand, does not have to be pumped to the location.

The size is selected with primary consideration to the fan horsepower requirements. The rating engineer selects the optimum amount of surface based on power costs. Reduction in surface can be accomplished, within limits, by increasing the air velocity and thus increasing the air-side heat-transfer rates, but this is done at the expense of higher fan horsepower. Usually the connected fan horsepower falls in the range of two to five hp per 1,000,000 Btu per hour, although variations beyond these limits do occur. The power requirements of a properly selected air-cooled heat exchanger are small in comparison with the usual cost of moving water or other liquid coolants because of the high efficiencies (70 per cent or more) of the axial-flow fans, and the short distance through which the air flows.

Fan brake horsepower is calculated from the formula:

$$\text{fbhp} = \frac{(\text{sp} + \text{vp}) \times \text{acfm}}{6370 \times \text{e}},$$

where fbhp = fan brake horsepower; sp = static pressure drop through unit; vp = velocity pressure of air stream; acfm = actual cubic feet of air per minute through fan; and e = fan efficiency.

Fan brake horsepower on many models may be varied to follow changes in ambient air temperature, or service requirements, with attendant saving in power costs. Multiple-fan units may be operated with some fans shut down, or fans may be equipped with two-speed, variable-torque motors. Fan-blade pitch is adjustable on all models. The controllable-pitch fan, with accessory instrumentation, provides almost infinite control of power requirements with a fixed-speed driver.

The maintenance cost of air-type coolers is very low. Corrosion and fouling from the coolant is almost nonexistent. Therefore the tubes and headers are usually selected of an alloy known to be adequately resistant to corrosion from the process fluid. As early failures on the air-coolant side of the tubes does not occur, these factors need not be considered in selecting materials of construction. Gears, motors and bearings used are designed for a minimum of attention and maintenance.

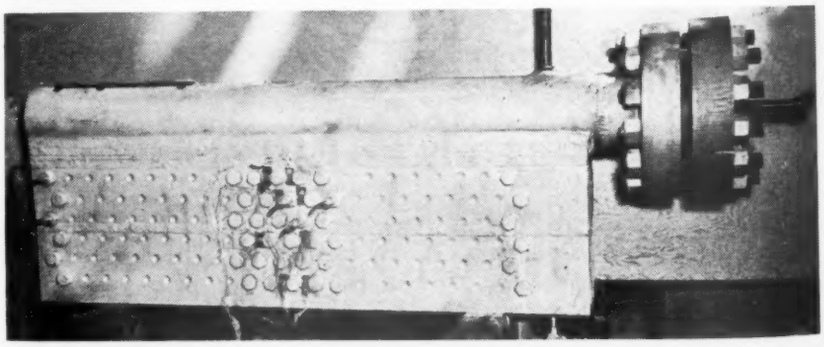
### Typical Pipe Line Installations

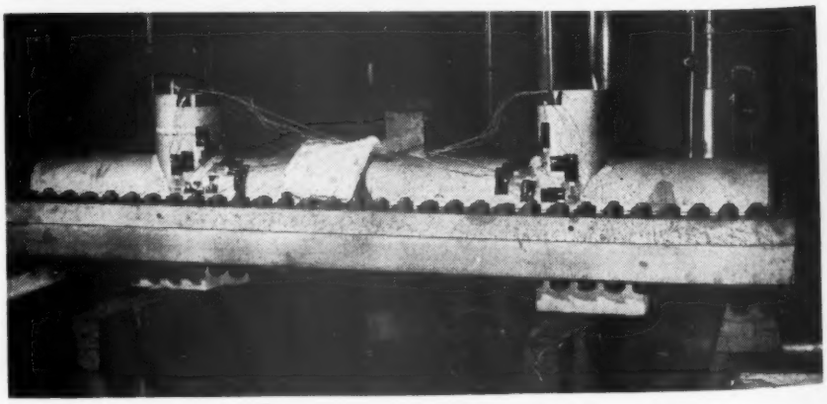
Use of air-cooled heat exchangers for both petroleum and gas pipe lines has been quite extensive. One American pipe line has 227. Several other lines have 30 or more in service.

The Middle-East pipe line of the Trans-Arabian Pipe Line Company has 105 finned-tube units. These units cool water for engine and generator jackets and lube-oil coolers, with ambient air at 122 F. As this air temperature is the maximum for only a small percentage of the year, each unit was

**FIG. 2. Top, is header used for after cooler on gas pipe line compressor. Header shown is box type and operates at pressures up to 2300 psi.**

**FIG. 3. Bottom, is high-pressure header developed for compressor intercooler and aftercooler.**





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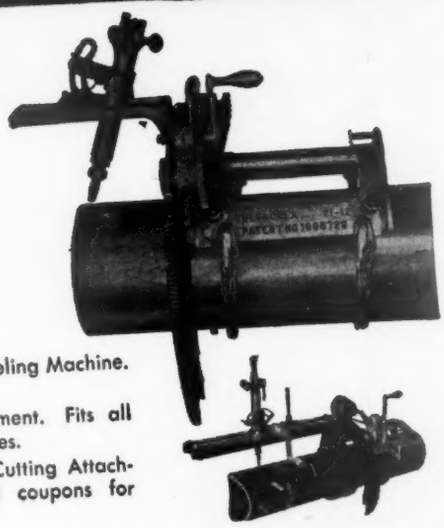

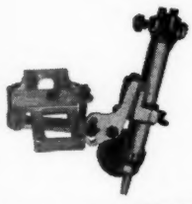

Illustrated above: Mathey Pipe Cutting and Beveling Machine. Cuts pipe at any predetermined angle.

Illustrated left: Mathey Out-of-Round Attachment. Fits all sizes of Mathey (and Mathey-made) Machines.

Illustrated right: Mathey Shape and Coupon Cutting Attachment. For cutting pipe intersections and coupons for welding analysis.



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provided with three fans. The number of fans in operation is established by the temperature control located in the water outlet. During the design of this installation the sequence of fan operation was calculated to establish the control points for the instrumentation. Table 2 indicates the maximum ambient air temperature at which excess fan capacity will cut-out and still maintain design heat dissipation.

For example, on unit A when the ambient temperature is 116 F or lower the middle fan will stop. When the ambient temperature is 93 F or lower the end fans will stop and only the middle fan will run.

Other methods for control may be used to suit individual requirements. E. L. Stark[4] discusses instrumentation wherein both fan capacity and outlet-stream temperature are regulated.

On some gas pipe lines air-cooled heat exchangers are used for compressor intercoolers and aftercoolers. The headers for the higher pressures are generally of the box type shown in Fig. 2. Low-pressure headers may be similar to that shown in Fig. 3.

**TABLE 2. Sequence of fan operation on pipe line.**

| Unit | Number of fans per unit in operation vs. ambient air temperature | | | BHP fan |
|---|---|---|---|---|
| | 3 | 2 | 1 | |
| A | 122 F | 116 F | 93 F | 3.8 |
| B | 122 F | 120 F | 111 F | 3.7 |
| C | 122 F | 117 F | 95 F | 5.1 |
| D | 122 F | 119 F | 110 F | 2.6 |

Header shown in Fig. 2 is used for an aftercooler operating at 2300 psi. The specifications for this exchanger were that it be built to the ASME Code, to meet the requirements of the local laws. This construction is not fully covered by the Code rules, hence a proof test had to be performed. This was done by installing strain gages both internally and externally. In addition the external surfaces were coated with a brittle lacquer. This header was tested at increasing increments of pressure to a maximum of 4420 psi, in the presence of a licensed inspector and the purchaser's engineers.


### Acknowledgment

This revised version of material originally published in Alco Products Review has been published through the courtesy of the American Locomotive Company, Schenectady, New York.


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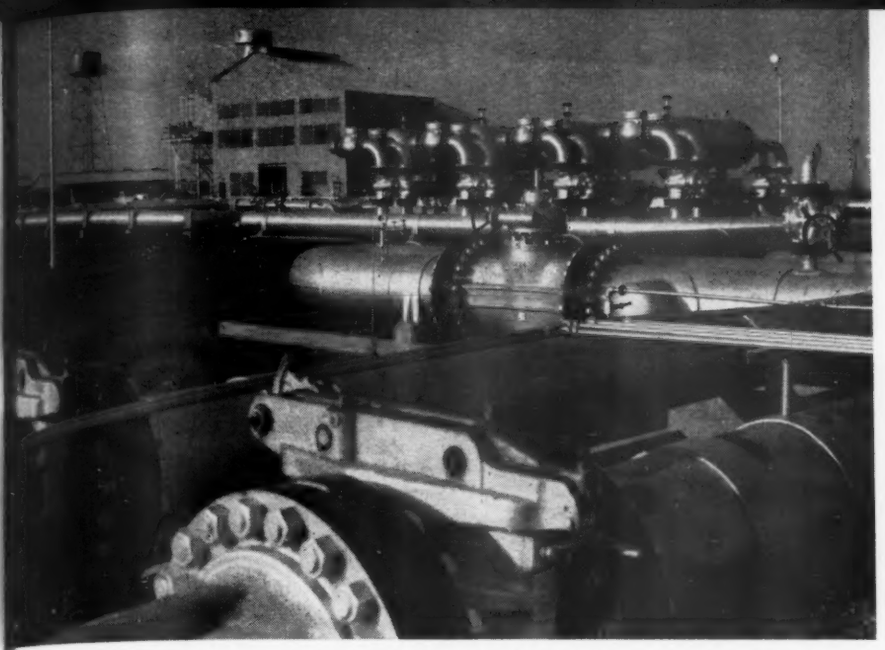

United Gas Pipe Line's new Napoleonville station is located on what was once a sugar cane field. View shows station in background, mainfold piping in foreground.

# NAPOLEONVILLE: *Station of Firsts*

*United Gas Pipe Line's first gas-turbine prime mover combined with company's centrifugal compressor is departure from past; special training is given for operating personnel*

THE impact of the age of jet power on the natural gas transmission industry is evidenced by the installation of a new gas-turbine-driven centrifugal compressor station by United Gas Pipe Line Company near Napoleonville, Louisiana.

The new station, put into operation recently, is on UGPL'S 30-in. main line, completed in 1952, which transports gas from offshore wells in the Gulf of Mexico and other South Louisiana fields to Kosciusko, Mississippi.

Besides marking United's initial use of turbine energy for compression of gas, it is the first centrifugal station of any type in the system. The other 33 active stations all have reciprocating, or piston type, engines.

Since being out on the line, the station has been instrumental in enabling United to surpass its all-time peak day delivery. On December 14, UGPL became the first and only pipe line company ever to deliver four billion cubic feet of natural gas in a day's time, and dispatching sheets showed that more than 500,000,000 cu ft of the record total had been pushed north in the 30-in. by the new centrifugal booster. Actual figure for the day was 510,992,000 cu ft. Since then it has pushed as much as 575,000,000 cu ft in a single 24-hour period.

In addition to being a new combination of prime mover and compressor, it is a departure from United's previous compressor station design in many characteristics, probably the most notable of which is its complete automatic control. In a matter of 15 min the unit can be put in service by energizing one master control switch. Once in operation, a network of electrical sensing devices feels the pressures, speeds, temperatures, etc., to insure proper control and safe operation.

Built to give gas an initial boost in the Napoleonville-to-Kosciusko line, it is located approximately three miles southwest of the town of Napoleonville in Assumption Parish. United's Bayou Sale 30-in., which extends offshore into the Gulf, and the 26-in. line from Lirette, form a junction at that point and are combined into a common stream on the suction side of the station. Gas pressures are boosted from approximately 795 psi to a maximum of 925 psi. This is followed by intermediate boosts along the 275-mile line at the Montpelier, Louisiana, McComb, Mississippi, and Jackson, Mississippi stations, each equipped with new natural gas engine reciprocating compressors.

### Turbine and Compressor

The turbine is a 5700-hp, two-shaft machine[1] fueled by natural gas from the pipe line. Fuel gas is burned with compressed air in the combustion chambers of the unit to provide a jet stream of hot gases which furnishes energy to drive the centrifugal compressor.[2]

The gas compressor itself, enclosed in a heavy case and somewhat similar in appearance to a centrifugal pump, works on a principle entirely different from the piston motion of reciprocating units. Radiating blades built around a shaft form an impeller or rotor that is spun at high speeds by the turbine. The compressor receives gas at a point near the shaft axis and compresses it by throwing it outward into a channel around its circumference. The shaft of the impeller is sealed by a mechnical device aided by oil at a pressure automatically maintained above the pipe line discharge pressure to prevent gas from escaping around the shaft.

The compressor rotates at speeds up to 5500 rpm and is designed to handle as much as 800,000,000 cu ft of gas in a day's time.

Use of turbine power to move gas by centrifugal compression is a recent development for the industry. The oldest such installation has been in operation only since 1948.

Reciprocating and centrifugal methods of compression are known to have different inherent characteristics and values that render one more applicable than the other for certain operating conditions. In some cases the centrifugal method is now regarded as the more efficient and economical. Under other conditions, use of the familiar reciprocating units is more desirable.

Principal use of turbine energy has been on long distance pipe lines where high flowing volumes and low compression ratios are needed. Some of the indicated advantages offered by such a unit include: Flexibility of speed at full load conditions, low building space requirements, push button station control, low maintenance costs, less operating supervision, less piping vibration and pulsation.

Piping vibration, an ever present problem to varying degrees in all recip-

[1]General Electric.
[2]DeLaval.



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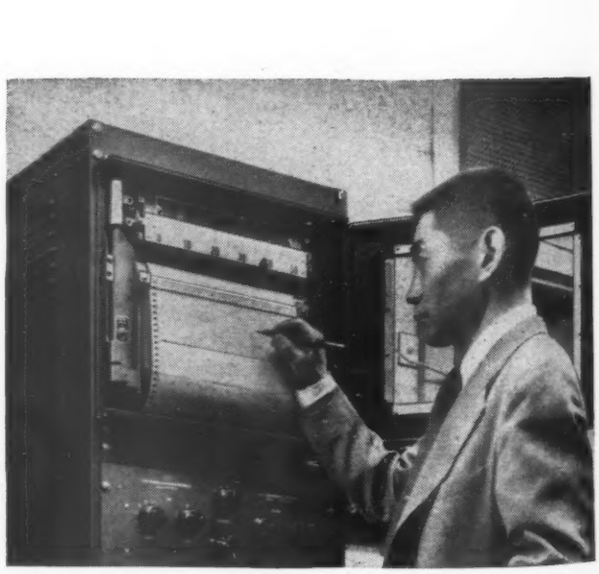
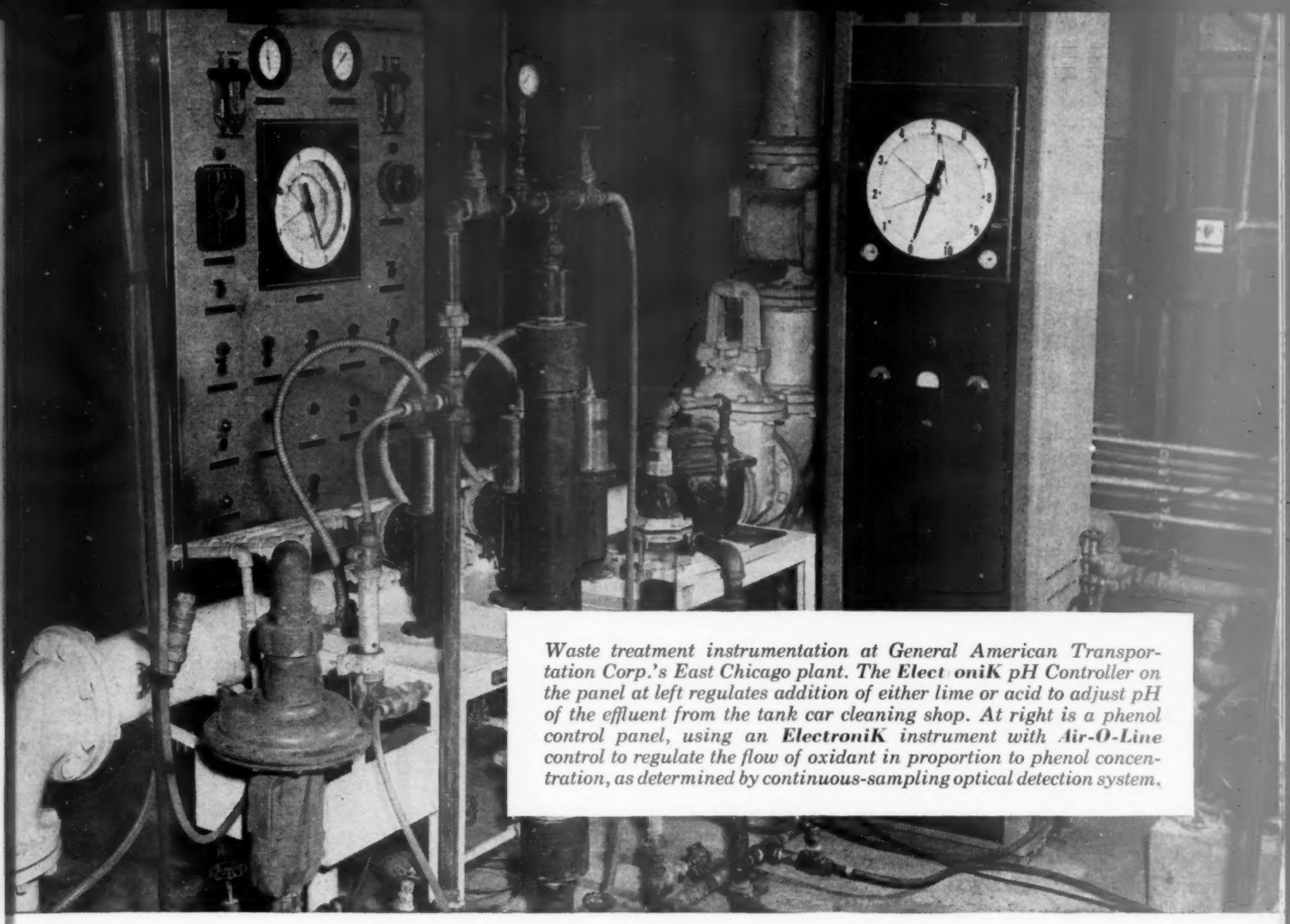


*Phenol concentration in final effluent at a large refinery is checked by infra-red spectrometer, which utilizes an* ***ElectroniK*** *instrument to record data.*



*Waste treatment instrumentation at General American Transportation Corp.'s East Chicago plant. The* **Elect oniK** *pH Controller on the panel at left regulates addition of either lime or acid to adjust pH of the effluent from the tank car cleaning shop. At right is a phenol control panel, using an* **ElectroniK** *instrument with* **Air-O-Line** *control to regulate the flow of oxidant in proportion to phenol concentration, as determined by continuous-sampling optical detection system.*

# *ElectroniK* instrumentation

MANUALLY regulated, batch-type treatment of industrial wastes is rapidly being superseded by fully automatic, continuous processes that utilize *ElectroniK* instrumentation to the fullest extent. The advancing technology of waste treatment recognizes that this problem is one of chemical engineering—and consequently can benefit by the same processing and control techniques that have sparked progress in production operations.

Instrumentation used by General American Transportation Corporation is an excellent example of modern methods. Used for the treatment of phenol and oil bearing wastes from tank car cleaning, it affords pin-point accuracy capable of detecting phenol concentrations as small as 0.001 part per million. Under control of *ElectroniK* instruments, the process functions continuously with minimum operating costs, reduced storage capacity and peak throughput. The instruments analyze chemical concentration, make a permanent record of effluent characteristics, and automatically regulate the addition of reagents.

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● **REFERENCE DATA:** Write for Bulletin 7302, "Instrumentation for Water, Sewage and Industrial Waste Treatment".

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rocating stations, is practically nil at Napoleonville despite the existence of a low load bearing soil in the area. This was one of the prime factors considered in selecting a turbine type unit.

### Turbine Building

The main turbine building is constructed of steel with corrugated asbestos covering, and of different design than the usual reciprocating compressor building. It rests on a 30-in. concrete mat that is supported by concrete composite steel piling driven to a sand strata 130 ft deep.

The turbine unit, compressor and the control room are all situated 14 ft above ground on a second story level in the building. The ground floor is used for station auxiliaries, exhaust, air and water piping facilities. The 125-ton regenerator, or heat-exchanger also rests on 130-ft piling.

Ground level on the station site, which was formerly a sugar cane field, had to be regraded and raised above one foot to provide sufficient drainage during the heavy seasonal rains.

### Turbine Weight Is 25 Tons

The turbine weighs approximately 50,000 lb and consists of a 14-stage axial flow air compressor, six combustion chambers, a first stage turbine which drives the air compressor, and the second stage or load turbine which drives the centrifugal gas compressor. The two turbine wheels operate on separate shafts and are divided by a set of variable nozzles to provide greater efficiency in operation. The nozzles are also shaped to enable the combusion gases to expand and hit the load turbine blades at the proper angle for the most effective impulse.

The air compressor, regenerator, combustion chambers and first stage turbine comprise what is known as the "hot gas generating set" of the unit. By burning natural gas and compressed air in the combustion chambers, it furnishes a fast-moving stream of hot gases to drive turbine wheels for both air compressor and gas compressor.

**Gas turbine that is being lowered in place during construction. This unit weighs approximately 50,000 lb.**

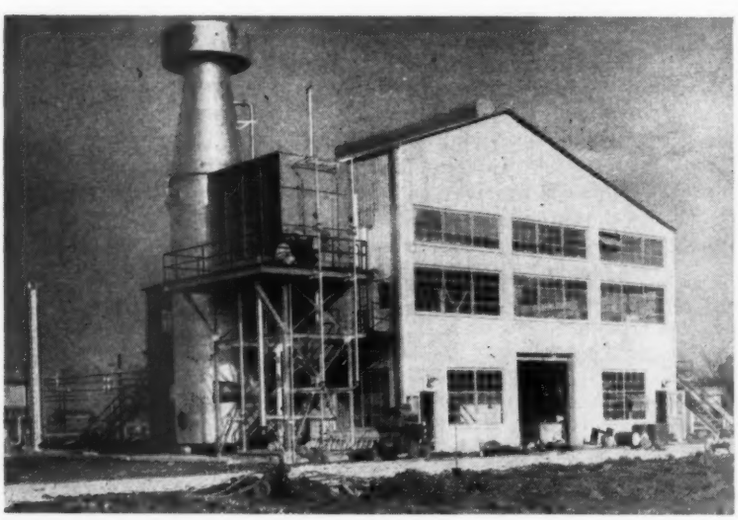
With the station running at full load, approximately 113,000,000 std cubic ft of air per day is compressed. This requires about 12,400 hp. An additional 5700 hp is produced to drive the centrifugal gas compressor, making a total of 18,100 hp developed within the turbine.

### Control of Turbine

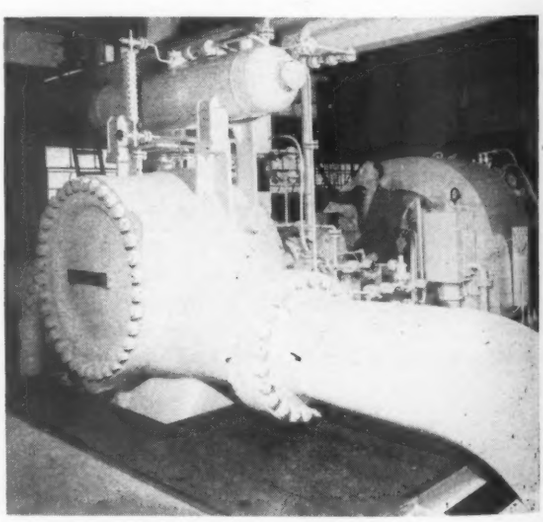
Turbine control is designed so that station operation can be automatically regulated by the discharge pressure. The pressure can thus be held to a desired point automatically adjusting the turbine speed in response to deviation from that point. If the turbine attempts to pull the suction pressure down below a set minimum in order to hold the discharge pressure constant, then the suction pressure automatically takes over and regulates the speed to keep the suction pressure from falling below the desired point.

Air for combustion, after being cleaned of dust, insects, etc., in an air washer, is gathered by the 14-stage axial flow air compressor that works in much the same manner as a series of fans. Each stage compresses the air a bit more until at the discharge end it is approximately five times atmospheric pressure and has a temperature of about 476 F. The air is then routed through the large regenerator where it picks up additional heat from the turbine exhaust gases, increasing the temperature to 800 F.

Air at this temperature and pressure enters the combustion chambers along with a metered supply of natural gas (at 150 psi) from the pipe line. When

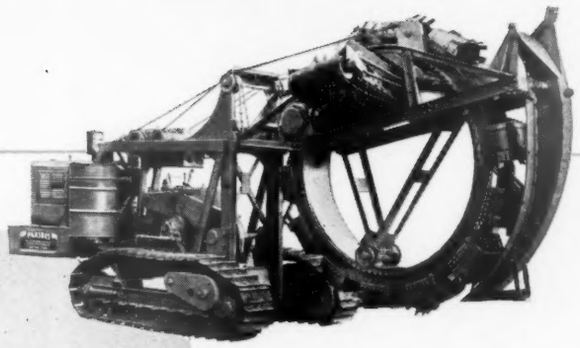


**Regenerator, where exhaust gases are used to heat air supply, rises above the main compressor building.**



**Chief Engineer C. W. Epps checks settings on compressor seal oil valves while standing between turbine and compressor units.**

# PUT THIS PARSONS 215 TRENCHLINER® IN YOUR PIPELINE SPREAD



**Opens 18 feet of trench per minute** With 30 digging feeds (from 5.9 in. to 18 ft. per min.) and 6 speeds on digging wheel (up to 11.2 r.p.m.) Parsons cross-country 215 Trenchliner produces up to 1080 lineal feet of trench per hour.

**Digs 6 feet deep, 13 to 31 inches wide** Square or round-bottom buckets on heavy-duty digging wheel are equipped with easy-in, easy-out "Tap-In" teeth — quickly installed, self-sharpening.

**Dual-purpose friction clutch** drives the digging wheel, and serves as an automatic safety — protects against shock loads. Wheel responds instantly to sensitive friction-clutch control, holds accurate grade.

**Arched wheel frame,** rigidly trussed, and 3 double-wheeled guide rollers, keep digging wheel precision-aligned. Rollers are all anti-friction bearing equipped.

**Shiftable, reversible conveyor** with 24-inch wide belt discharges spoil to either side of machine. Conveyor belt speeds are synchronized with digging wheel speeds.

**Standard tractor crawlers** have 18-inch treads and lug-type shoes, for work on grades and soft-footing. Ground bearing pressure is only 6 pounds per square inch.

**Choice of 2 standard diesel engines** (55 h.p.) lets you fit this 215 Trenchliner right in with other equipment in your pipeline spread. Simplifies operation and maintenance programs, means more work-time.

*Your Parsons distributor has more information that will interest you. See him, or write.*

**Other Parsons Trenchliners include: Wheel-type 202 for utility and drainage work; 3 ladder type Trenchliners, full crawler mounted, and rubber-tired utility Trenchmobile®.**
*(Koehring Subsidiary)*

*Send us literature on 215 Trenchliner.* **PARSONS COMPANY, NEWTON, IOWA**

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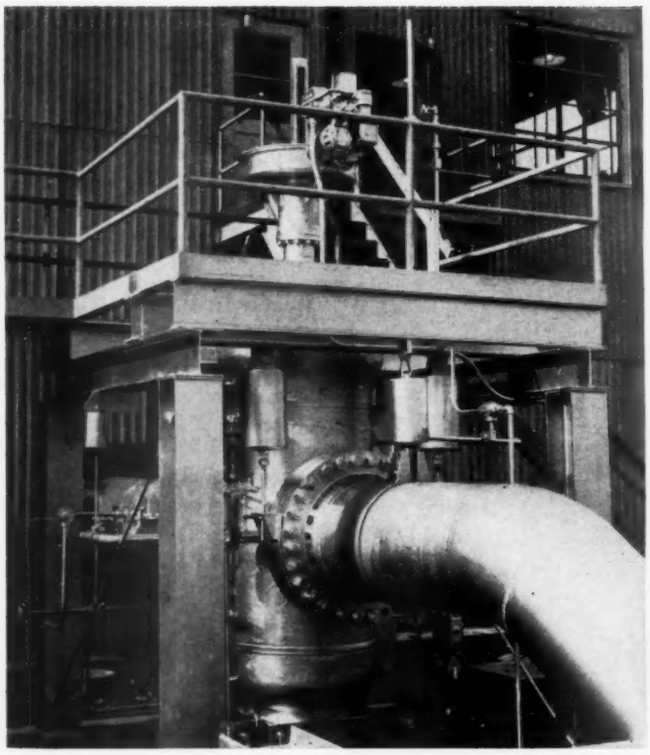
STREET _____
CITY _____ STATE _____ P475PE



XUM



**Compressor valve and automatic valve operator, with main engine building in background.**

**Station can be put into service by turning single control switch, shown here by First Engineer Woerndel.**

ignited, combustion takes place with an excess of air to form a mass of hot gases at a temperature of about 1450 F. As some of this energy must drive the air compressor, the gases are first expanded through a set of stationary nozzles and directed against the blades of the first stage turbine. Losing only a part of their energy here, the fast-moving hot gases pass through another set of nozzles — positions of which can be varied — to hit the blades of the load turbine. This turbine wheel is coupled to the gas compressor, and its drive is what determines the actual output of the station.

After the gases have passed through both turbines they are still quite hot, normally about 880 F. Some of this heat is saved by transferring it in the regenerator to the fresh supply of compressed air heading for the combustion chambers. The transfer of heat takes place as the air flows around hundreds of small pipes through which the hot exhaust gases pass to the atmosphere.

Each turbine has a set of nozzles which convert the pressure energy in the hot gases to velocity energy. It is this velocity energy which then strikes the blades making up the turbine rotors and turns them at high speed. In the case of the load turbine, the nozzles are movable and can be varied to change the amount of conversion of pressure energy to velocity energy.

### Fuel Regulation

Two methods of control that help govern the turbine's performance are regulation of the fuel supply and changing position of these variable nozzles, which are located in the passageway between the first stage turbine and the load turbine. Both conditions are controlled automatically.

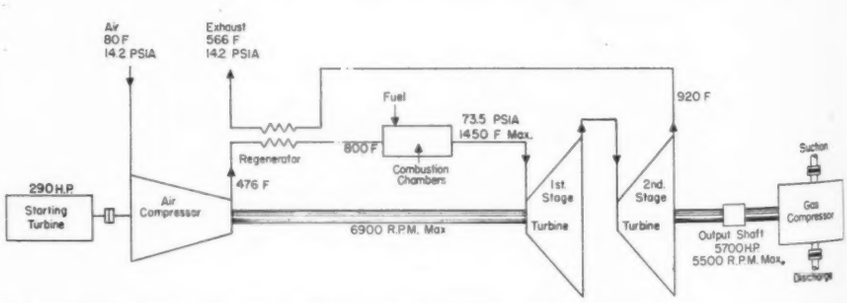
Rate of fuel flow into the combustion chambers is governed by a fuel regulator that receives a number of signals that cause it either to increase or decrease fuel. The signals include: Station discharge pressure, speed of the load turbine, temperature of turbine exhaust, fuel requirements when starting, and selected speed setting. By adjusting fuel flow, speed of the load turbine can be varied from 2000 to 5500 rpm to effectively meet pipe line needs.

### Variable Nozzles

When the station is running at full load, the variable nozzles remain in a definite position calculated to provide greatest operating efficiency. When the station is handling light loads, however, there is a close connection between the amount of fuel used and position of the nozzles, which are actuated by an automatic nozzle regulator that is governed by speed of the gas generating set and the exhaust temperature.

By operating with automatic control of the nozzles, efficiency can be stepped up from several standpoints. Excessive overspeeds in the turbine can be prevented by tripping the nozzle wide open. The amount of fuel can be reduced for light pipe line loads. The turbine will handle better at high inlet air temperature. Required starting power can be reduced. The plant can be run at no load without exceeding the rated speed of the load turbine and without running at excessively high exhaust temperatures.

Overspeed protection is also provided by governors attached to each




**Schematic diagram of Napoleonville gas-turbine-compressor.**

# Lifeline for industry

THE VAST NETWORK of pipe lines criss-crossing America are actually *lifelines* . . . for they transmit gas, oil and water essential to industry.

For the past four years we have been helping to extend these lifelines by shipping more than 24,000 carloads of Basalt-Kaiser Steel pipe to major projects throughout the country. This is enough to build a pipe line from Juneau, Alaska to The Panama Canal.

All of this steel pipe has been delivered *on time.*

This dependable delivery—plus *uniform quality, wide range of sizes,* and *prompt service*—is another reason why experienced pipeline companies know they can rely on Kaiser Steel.

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**KAISER STEEL PIPE SPECIFICATIONS • All pipe manufactured to latest A.S.T.M. and A.P.I. specifications**

| Type | Diameter | Length | Wall Thickness | Shipping Point |
|---|---|---|---|---|
| Continuous Weld—Threaded and Coupled | ½" to 4" nominal I.D. | Uniform 21' | Standard | Fontana, Calif. |
| Continuous Weld—Plain End | 2⅜" to 4½" O.D. | Up to 40' | Standard | Fontana, Calif. |
| Electric Resistance and Fusion Weld—Plain End | 14" to 18" O.D. | Up to 40' | .250" to .500" | Napa, Calif.—Basalt-Kaiser |
| Electric Resistance Weld—Plain End | 5⅝" to 12¾" O.D. | Up to 55' | .188" to .375" | Fontana, Calif. |
| Electric Fusion Weld—Expanded—Plain End | 20" to 30" O.D. | Up to 40' | .250" to .500" | Napa, Calif.—Basalt-Kaiser |

**Prompt, dependable delivery at competitive prices • KAISER STEEL CORPORATION** Los Angeles, Oakland, Seattle, Portland, Houston, Tulsa, New York

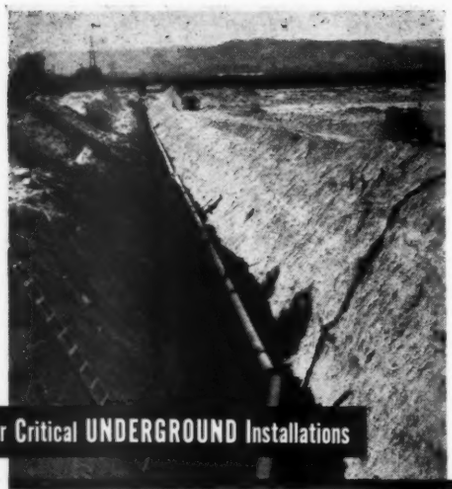


To obtain more information on products advertised see page E-61



XUM

# a SOMASTIC® pipe coating for every need!



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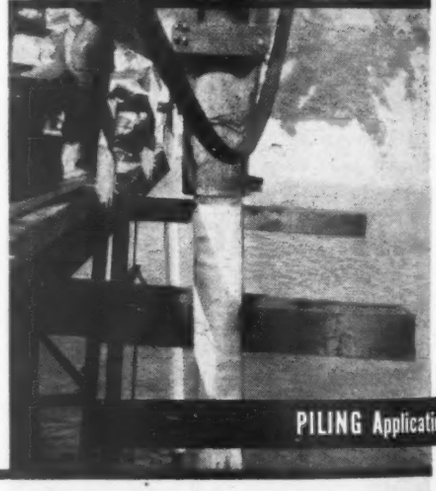

PILING Applications

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SOMASTIC is available in a number of formulations. Each is an asphalt-mastic designed for continuous, uniform, seamless, impermeable protection. Carefully engineered mechanical characteristics permit SOMASTIC Coated Pipe to withstand stock piling, field hauling, and rough handling that would rupture or distort other types of coatings. For BIG INCH lines. For SMALL INCH lines. For REHABILITATION. For water, gas, hot oil . . . under really tough corrosive conditions.

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## ONE gives you FOUR!

1. SOMASTIC Pipe Coating

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Cement Mortar Interior Lining of Pipe Lines "in place" using . . .

2. The TATE Process
(for 4" to 16" pipe)

3. The CENTRILINE Process
(for 16" to 144" pipe)

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4. Centrifugally Spun Cement Mortar Lining of pipe 4" to 16"

**Chief Engineer Epps checks turbines fuel regulator. Air intake of unit at top and starting turbine at lower right.**

**Combustion chambers of the turbine where gas and air are burned, providing fast moving stream of hot gases for unit.**

turbine shaft and operated independently of the normal speed controls.

In event of excessive overspeeds in either the first stage turbine or the load turbine, they act automatically to stop the fuel gas, thereby shutting down the entire unit. During normal operation the turbine is protected by many such sensing devices.

### Control Room

All controls for starting, operating and stopping the turbine and for regulating station pressures are located in the control room, which is separated from the main engine room by a solid wall fitted with vapor-proof glass panels. An annunciator to warn of abnormal operating conditions is mounted on the control panel in the room. Any irregularity in the control points is flashed to this panel, which rings an alarm and drops a tab indicting source of the trouble. If it is of serious nature the station will automatically shut down and by-pass the gas.

The control panel also houses a 48-point temperature recorder, vibration recorder, speed indicator and other necessary devices to operate the turbine.

Station suction and discharge valves and the main line valves can be push-button controlled from this room. The station can be isolated from flowing gas and bypassed by pressing a single switch. In event of a large drop in pressure on either the suction or discharge lines, this occurs automatically.

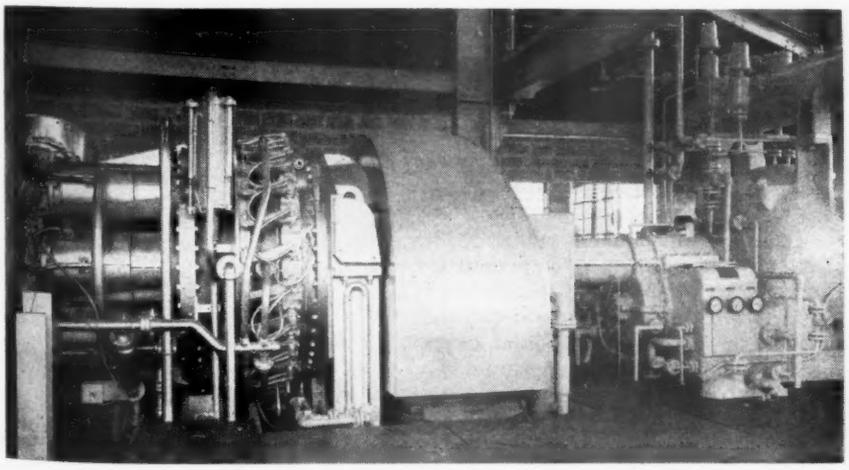
Remote control operation of the various valves is by valve operators, which are actuated by gas from the pipe line and electrically controlled by power from the station batteries.

### Starting Turbine

Gas for starting and operating the turbine is taken from the main line, reduced in pressure and separately measured by orifice meters. When placing the station in operation a single switch is pressed in the control room to initiate the starting sequence. The large turbine is rotated by a small starting turbine operating on pipe line pressure and requiring about 35,000 cu ft of gas at 150 psig to start. It engages the station turbine by means of a clutch operated by air pressure.

The starting turbine brings the gas turbine up to 10 per cent speed, where it is purged for about five minutes to remove all traces of gas, then fired and accelerated to idling speed. As it reaches operating speed the starting turbine is disengaged and shut down. During the starting cycle the lubricating oil and cooling water systems are also energized, and the main gas valve automatically opened. Upon completion of the entire sequence the discharge pressure controller takes over speed control of the turbine and maintains the pre-set output.

When a stopping signal is given, the fuel is automatically shut off, the main suction and discharge valves and the compressor by-pass and purge valve



**Operator's view of 5700-hp, 2-shaft turbine; fueled by gas drawn from pipe line.**

CLEANING, COATING, WRAPPING & RECONDITIONING

★

# HOT DOPE

## Straight from the Kettle on *PIPE PROTECTION*

★

*By Boyd Mayes*

• Saw some place recently where one of those Oil writers said: "PIPELINING IS EVERYBODY'S BUSINESS." With this, we surely agree. We're not talking about just the side he was adding up — we're talking about the human side — how much benefit that gas pipelining has brought to all of us. Reckon there's a whole new generation growing that will never know what it is to chop kindlin' and tote wood for a kitchen stove or fireplace. They'll just light a match — turn on the gas — and there she goes — thanks to good pipelining— and progress. Another interesting thing recently noted is the amount of chemical pipelining. Folks would be surprised how much butadiene, styrene, chlorene, propylene, etc. pipelines carry under the Texas Gulf Coast. Yes, pipelining is big business and we are happy to be a part and offer our facilities to everyone who needs coating, wrapping and reconditioning service for pipe. We've been at it 26 years and have the best men in the business to handle it.

**MAYES BROS.**

1150 McCarty HOUSTON, TEXAS Orchard 7566


are opened. The gas compressor turbine shaft will come to rest in approximately 6 to 8 min. and the air compressor turbine shaft in about 15 min. The lubricating oil pump runs for about 30 minutes after the unit stops to keep the bearings cool. Restarting can take place as soon as both shafts come to rest.

### Station Auxiliaries

Station auxiliaries are either driven direct from the shaft of the turbine, or are electrically powered by purchased alternating current or by direct current from storage batteries. In case of a power failure, a gas engine driven standby generator supplies the minimum alternating current requirements. Battery power is used for some of the turbine auxiliaries and to actuate all the valve operators and automatic controls.

### Acknowledgement

Acknowledgement is made to *United Gas Log* and United Gas Pipe Line Company for the material and photographs used in preparing this article.

☆ ☆ ☆

## Training Program

BECAUSE operation of its new gas turbine-driven centrifugal compressor unit marked a departure from previous methods and is a new experience for personnel, crew members for the station were selected and training of the group began many weeks before the station was put into service.

To help the men make the transition from reciprocating engines and pumps to the new turbine unit, the general office training section of United, in collaboration with the compressor station and engineering departments, initiated an extensive training program.

Approximately 424 man hours of formal training was given the group, and this was preceded by many hours of informal training by United chief engineer, C. W. Epps, first engineer, L. C. Woerndel, representatives of General Electric, and UGPL engineers, during the time the equipment was being installed.

Early training work included assembly by the training section of an illustrated booklet, "Introduction to the Napoleonville Station;" a study of station piping and valve operation; study of valve operators by a factory representative; a class on operation of the relief valve, which automatically bleeds pressure off the line when it becomes too high, and an explanation of remoted controls, emergency shut-down, and station auxiliary pressure switches by M. G. Wallington of the general office.

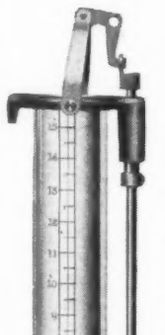
Other sessions included overall tur-


W. L. WALKER CO.

# SINGLE TRIPPING

## WALKER OIL THIEF

*Cuts Gauging Time*



Take samples faster with the Walker Oil Thief. A trouble-free Single Tripping device enables the gauger to trip the thief at any depth with one quick jerk. Only one chain or rope required for lowering and tripping the thief.

Other exclusive features include: a rotating valve seat to assure proper seating; encased springs to prevent fouling; trip mechanism which accommodates any length trip rod. Sturdily built for longer service. Available in five sizes: 12, 16, 18, 24 and 36 inches. Available through all supply stores.

QUALITY WLW SERVICE

- CENTRIFUGE MACHINES
- GAUGING TAPES
- SAMPLE HEATERS
- STRAPPING KITS
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*Everything the gauger needs from one dependable source.*

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# Westinghouse Microwave Letter

WESTINGHOUSE ELECTRIC CORPORATION, ELECTRONICS DIVISION, 2519 WILKENS AVE., BALTO. 3, MD.

## Multiplex Assembly Combines Frequency Division, Unit Design, Crystal Control

The many useful functions of a microwave communications and control system rely heavily on the merits of its multiplexing equipment. So fundamental is this equipment to overall microwave dependability that Westinghouse placed first emphasis on superior multiplex design in creating its 2000 MC system.

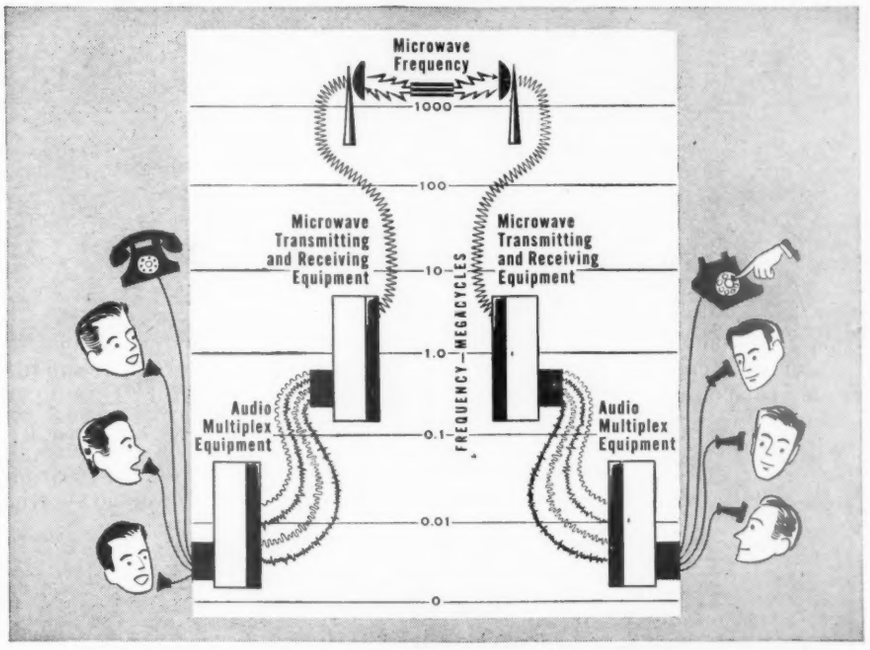
### Strict Channel Independence

Years of Westinghouse experience in microwave communications — and in control systems generally — are the basis for this latest design. User requirements, freshly evaluated, pointed to the single most important "basic" of a microwave system: multiplex channels must be as independent of each other as possible. Westinghouse 2000 MC Microwave achieves this independence to a remarkable degree — and thereby attains an exceptionally high level of communications reliability for both voice and control.

For strict channel independence, Westinghouse 2000 MC multiplex equipment (called Type FJ) includes three interfunctional elements: self-contained voice and telegraph panels . . . crystal control of each and every frequency . . . multiplexing by the completely efficient method of frequency division. The result: if one channel develops a fault, all other channels continue to operate without interruption.

### Individual Power Supplies

Type FJ equipment includes only four panels: Voice Band Panel, Telegraph Transmitter, Telegraph Receiver and Telegraph Power Supply Frame. These basic units supply up to 30 voice or telegraphic channels or any required combination—a capacity fully able to meet most present and future needs. Even greater telegraphic capacity is available by submultiplexing each channel with up to 15 additional telegraphic functions.




*Frequency-division multiplexing in Westinghouse 2000 MC Microwave: individual audio signals modulate Type FJ Multiplex units (300-600 KC range)... composite output frequency modulates Type FR Radio (2000 MC band).*

The Type FJ panels are so completely flexible that they operate on any channel frequency, requiring only a change of crystal and retuning. Each Voice Band Panel is entirely self-sufficient, even to having its own individual power supply. There is no reliance on a central supply that would, upon failure, incapacitate the whole or a critical part of the microwave system.

### Simpler Circuits, Stable Frequencies

Westinghouse microwave takes full advantage of the inherent reliability of frequency-division multiplexing by incorporating simpler circuits. Maintenance savings are increased . . . personnel training is made easier. Reliability is further assured through crystal control of frequencies. High stability results, providing frequency coordination over wide ranges of input voltage, temperature, and other variable conditions.

Westinghouse 2000 MC Microwave radio equipment is as carefully designed and engineered as this flexible, reliable multiplex equipment. Westinghouse microwave equipment benefits from the years of valuable manufacturing and application experience Westinghouse has had with all types of end-use devices. For full information call your Westinghouse representative or write: Westinghouse Electric Corporation, Electronics Division, Microwave Section, 2519 Wilkens Avenue, Baltimore 3, Maryland.

***Ask for our Microwave Booklet.***

**YOU CAN BE SURE... IF IT'S Westinghouse**

J-02277

Class discussing operation of relief valve.

Drawings are compared with actual equipment.

## New Equipment Meant Special Training Program for Personnel

bine operation and control, and compressor operation and control.

Receiving special emphasis in the training program were principles of effective teaching, so that members of the original Napoleonville operating crew will be ready to pass on their training to new employees at the station or to personnel at any future turbine-driven station on the United Gas System.

All of the operating personnel selected for operation of Napoleonville station had previously worked at reciprocating stations, and included, in addition to Epps and Woerndel, B. E. Clark, W. B. Taylor, V. V. Thompson, and Sable Bush.

Seven company residences were constructed on the station yard for employee housing. * * *

Various parts were disassembled, studied, left.

Right, members of the operating crew at Napoleonville station in class session. Left to right are C. W. Epps, chief engineer; R. A. Toups, maintenance man; V. V. Thompson, engineer; F. L. Barbier, maintenance man; Sable Bush, engineer; L. C. Woerndel, first engineer; Emerson Sonier, oiler-engineer, and V. W. Bachus, division engineer from general office compressor station department.

# Allis-Chalmers Powerful HD-15 adds to its big work advantages

**. . . now offers choice of two outstanding drives — standard transmission with time-saving shift pattern, or widely accepted hydraulic torque converter drive**

From its introduction, the Allis-Chalmers HD-15 has set new standards in performance and long-life service . . . in a new size class. It combines outstanding strength and balance with plenty of power, plus a simplified, time-saving transmission that gives big work output. In addition, the HD-15 offers remarkable service simplicity, with features like unit assembly and 1,000-hour lubrication intervals for truck wheels, idlers, and support rollers. It has proved itself the kind of tractor required on today's jobs.

*Now,* hydraulic torque converter drive is added as optional equipment — an additional working advantage for the powerful HD-15. This advanced design drive was introduced by Allis-Chalmers in the world's *first* torque converter tractor nine years ago. This modern drive gets more done because it automatically provides the right combination of speed and pull every working minute . . . and hydraulic cushioning assures longer life for both tractor and auxiliary equipment.

Now you can choose the HD-15 with standard transmission *or* hydraulic torque converter drive. Either way you'll be getting the most advanced tractor in the business. Let your Allis-Chalmers dealer give you *all* the reasons why.

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TORQUE CONVERTER

*Symbol of greater output, longer life.*

**Flames leap up as gas remaining in line after blow-down ignites when pipe is cut in half. Pressure was dropped from 725-800 psi to atmospheric in section of line where crossovers were connected.**

P 622

# "Operation Crossover" Adds Safety Factor

*Addition of crossover connections at 10-mile intervals on loop lines insures Texas Gas uninterrupted deliveries*

JOHN POTTER*

SAFETY played a role in the planning of a series of crossover connections installed recently by Texas Gas Transmission Corporation between its parallel 26-in. pipe lines.

The principal thought behind the planning of the crossovers, as is the case in all such instances, was that they would make possible uninterrupted deliveries of gas to customers along the route of the line even if it should become necessary to shut down any section of them for maintenance or emergency repairs.

In 1952 and 1953, Texas Gas, which operates a nine-state natural gas transmission pipe line system from Texas to Ohio, laid 408 miles of 26-in. line parallel to another 26-in. line that had been installed in 1948 and 1949. In planning the new line, Texas Gas engineers took into consideration the advisability of connecting it every few miles to the original one with the added safety factor of a lateral tee side connection rather than hot tap the original line.

They scheduled, and construction crews installed, twin 20-in. crossover lines between the transmission lines about every 10 miles along the route. A valve is located in each crossover and in each 26-in. line between the two

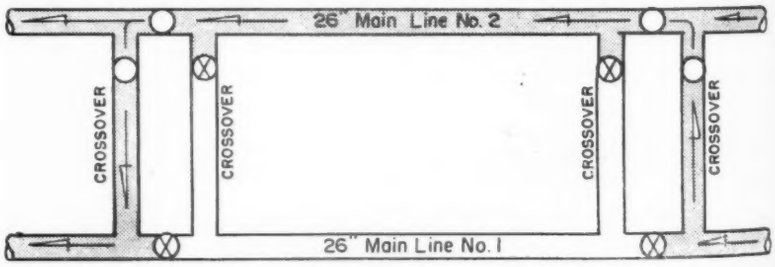


**FIG. 1. Diagram shows how crossovers can be used in event emergency repairs or maintenance caused one line to be shut down.**

**EXCLUSIVE**

*Texas Gas Transmission Corporation, Owensboro, Kentucky.

# What's worth metering is worth metering right!

**. . . and Foxboro offers the *right* meter for any metering problem. Round and rectangular cases. See the varied types below.**

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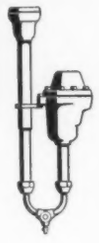
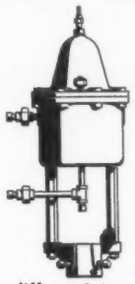
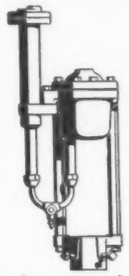
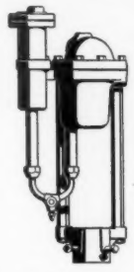
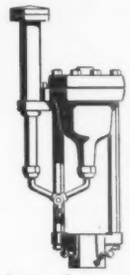
|---|---|---|---|---|
|  |  |  |  |  |
| light weight and low cost, preferred for portable recording, or with 6" indicator, for mounting directly on piping. | for differential ranges as low as 1" $H_2O$, especially for low pressure gas and air service. | superior general use meter with all Foxboro design features for high sustained accuracy and maintenance-freedom. | longer float travel, greater power, highest accuracy meter ever built. | leakproof measurement at really *high* pressures without compromise in accuracy. |

## a flow meter type for every need

From its complete line of flow meters, Foxboro can offer the *best* type — in the proper range and static pressure rating — for virtually any metering problem. They are available as indicators, recorders, controllers, and transmitters — with or without integrator. Foxboro also is the maker of the d/p Cell — the compact force-balance type flow transmitter which uses no mercury.

The widest selection of flow instruments is only one of the many factors responsible for Foxboro's acknowledged leadership in flow metering. See how this factor — together with many superior, exclusive design features — give you the most value for your money. Write for Bulletin 460 on mercury meters, Bulletin 420-1 on d/p Cells.

***Specifications of Foxboro Meter Types Illustrated***

| TYPE | MATERIAL | MAX. W. P. | RANGES |
|---|---|---|---|
| 22 | Forged Steel | 2000 | 20"—200" |
| 29 | Cast Iron | 150 | 1" —10" |
| 27* | Forged Steel | 2000 | 10"—400" |
| 28 | Forged Steel | 2000 | 50"—400" |
| 26 | Forged Steel | 5000 | 100"—400" |
| d/p Cell | 316 S.S. | 750-4000 | 25"—800" |

*Type 27U is a uniform flow scale meter used for steam and other service where demand fluctuates widely. 100" range. Max. W. P. 2000 psi.

THE FOXBORO COMPANY, 749 NEPONSET AVENUE, FOXBORO, MASS., U.S.A.

**FOXBORO** REG. U.S. PAT. OFF. **FLOW METERS**

FACTORIES IN THE UNITED STATES, CANADA, AND ENGLAND

**Prefabricated "tee" of 20 and 26-in. pipe, constructed by Texas Gas' own pipe line department, is lowered in place preparatory to making the connection. Safety guided all moves made in operation.**

crossover line taps (see Fig. 1) to make it possible to route gas around any section of either main line during off-stream internal cleaning, maintenance or repair operations, or in an emergency.

The 50-ft long crossover lines, each with a 26 by 26 by 20 welded tee at either end and with a 16-in. valve nearest the new transmission line, were fabricated by Texas Gas pipe line department.

Installation of each crossover line was a two-phase operation. The end of the crossover containing the valve was installed at the time the new 26-in. line was laid and before gas was turned into it. This was followed by the eight to nine-hour job of blowing down sections of the gas-filled original line between crossover locations, cutting into it, installing the tees and sections of 20-in. pipe that completed the crossovers, purging and equalizing pressure.

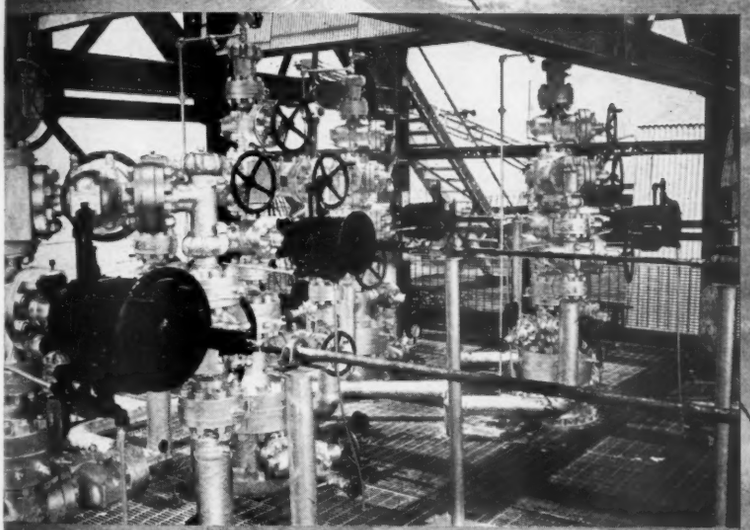
Prior to blowing down the line from 725-800 psi to atmospheric pressure at each crossover point, Texas Gas took the precaution of notifying residents of the areas that great noise would be heard. This notification was given through personal contacts, newspaper articles and radio announcements, and eliminated alarm that has attended unannounced blowdowns. * * *

**Working against time, two welders begin securing the tee section to the twin 26-in. lines. Time consumed for each operation, including blow-down, installation, and pressure equalizing varied between 8 and 9 hours.**

*for that big one off shore*

# E-I-M

*stands the Test...*



**It's just like fishing with a heavy test line when you install E-I-M Valve Controls. You can be sure that the well won't get away from you because E-I-M has a record of safety and dependability. Our engineers can solve your transmission problems with E-I-M Valve Controls for oil or gas lines off shore or across the continent.**

The Pure Oil Company's platform in Rollover Field, 9 miles off the Louisiana coastline, has four producing wells, each using an E-I-M Valve Control for maximum safety to protect personnel and the platform.

**E-I-M Company** INCORPORATED

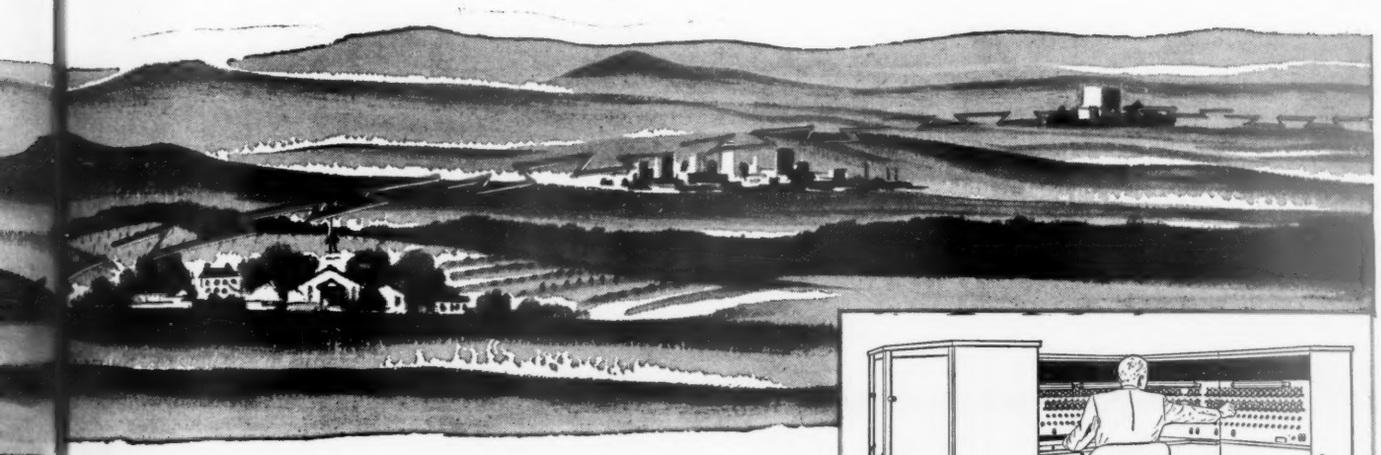
1340 OLD SPANISH TRAIL • HOUSTON 21, TEXAS • MOhawk 4587

Valve Controls • Speed Reducers • Cooling Tower Drives • Control Valves

# ANNOUNCING

SEE OUR EXHIBIT
AT THE
P.I.E.A. CONVENTION
IN DALLAS
APRIL 6, 7 and 8

# Transport CENTRALIZED TRAFFIC CONTROL FOR PIPE LINES



• Just one dispatcher can operate any piece of equipment or entire stations on your pipe line with the UNION Centralized Transport Control System. By flipping switches he can control pumps and operate valves on the line 50, 100, 200 or more miles away. A glance at his control panel can give him accurate operating information for an entire pipe line. At his fingertips he has control over all functions at all stations in the C.T.C. System. C.T.C. operation is fast, sure, and efficient.

You have these cost-saving advantages on existing as well as new pipe line systems . . . using your present communication system. UNION Centralized Transport Control works equally well with line wires, carrier, or microwave.

Reliability is proved. We've been building control equipment for railroads for 70 years and Centralized Traffic Control systems for 25 years. C.T.C. installations are designed for your individual requirements. Equipment is built for many years of rugged, fail-safe operation. Field maintenance when required, is simple and fast.

Send the coupon for more information.

**C.T.C. . . . Proved reliable for over 25 years on American railroads**

"Union" Centralized Traffic Control has been highly successful on America's heavily traveled railroads. Now, this same engineering skill is being applied to control the transport of petroleum products and gas in pipe lines. The problems are very similar and the extensive experience possessed by Union Switch & Signal makes it eminently qualified to design and produce Centralized Transport Control for pipe lines.

**UNION SWITCH & SIGNAL**

**DIVISION OF WESTINGHOUSE AIR BRAKE COMPANY**

PITTSBURGH 18 PENNSYLVANIA

NEW YORK CHICAGO ST. LOUIS SAN FRANCISCO

General Apparatus Sales, Dept. PE-67
Union Switch & Signal
Div. of Westinghouse Air Brake Co.
Pittsburgh 18, Pennsylvania

I want the facts on how UNION Centralized Transport Control can improve pipe line operation and cut costs. Please send your booklet.

Name .....

Title .....

Company .....

Address .....

City & State .....



XUM

# Pipe Line Pictorial

ANNUAL operating section meeting of the American Gas Association on supply, transmission, and storage in New Orleans, highlighted current trends and developments in communications, compressor stations, large volume gas measurement, pipe line maintenance practices, underground storage, natural gas production, dispatching, and pipe line construction methods.

**Checking the program are Keith R. Reid, Aluminum Company of America, New Orleans, left, and L. S. Reid, Department of Natural Gas Engineering, University of Oklahoma, Norman. They aren't related.**

## AGA Supply, Transmission, and Storage Conference Held

**Pre-meeting conversation found together, left to right, Herb King and F. Zappfe, Lone Star Gas Company, and Leo Polderman, Carbide and Chemical Company, New York City.**

**Congratulating operating section chairman Fred Pfluke, right, on a very successful meeting are John H. Wolfe, Consolidated Gas, Electric, Light and Power Company, Baltimore, and A. D. Harrison, Brooklyn Union Gas Company, Brooklyn.**

**Found at the Pipe Line Luncheon conference were, left to right, T. D. Williamson, Jr., T. D. Williamson, Inc., Tulsa; Clint McClure, El Paso Natural Gas Company, El Paso, and Roland B. Pinkston, Lake Shore Pipe Line Company, Ashtabula, Ohio.**

**Lobby conference was held by, left to right, J. J. Corrigan, assistant pipe line superintendent, Transco; F. E. Culvern, compressor stations engineering, Panhandle Eastern, Kansas City, and W. E. Scott, superintendent of stores, Panhandle Eastern, Kansas City.**

Time out from serious talk for a picture was taken by, left to right, Walter H. Davidson, general superintendent of operations, Transcontinental Gas Pipe Line Company; Dwight Sprow, general superintendent, Natural Gas Pipe Line Company of America; J. R. Wait, Jr., Houston Pipe Line Company chief engineer, and J. E. Cunningham, The Fluor Corporation, Houston.

Between meetings in the Tulane Room photographer found, left to right, William R. Rice, Brown and Root, Houston; Harvey Lewis, Midwest Piping Company, Houston, and Dr. John E. Brock, Midwest Piping Company, St. Louis.

# New Orleans AGA Meeting Draws 500 Operating Men

At the meeting special emphasis was given to pulsation exploration and effect on gas measurement, drilling wells with gas or air as circulating medium, relations with the FCC in communication matters, interconnected gas systems, petrochemicals, and the ASA code for pressure piping.

Relaxing in the mezzanine lobby are left to right, H. A. Gehres, Cooper-Bessemer, Mt. Vernon, Ohio; C. H. M. Burnham, vice president, Panhandle Eastern; Charles L. White, Cooper-Bessemer; and Dwight Sprow, Natural Gas Pipe Line Company.

Operating problems were discussed by George S. Leachman, Peerless Manufacturing Company, Dallas; W. E. Almquist, Blaw-Knox, Pittsburgh, and C. M. VanSlyke, Transco, Decatur, Georgia.

Transcontinental Gas Pipe Line men taking time out between meetings are left to right, H. L. Cline, assistant superintendent compressor department; J. L. Hamilton, Baton Rouge, and E. C. Link, superintendent gas control.

Talking over current trends are, left to right, G. H. Martin, chief engineer, Union Gas Company of Canada; A. J. Elbert, National Tube Company, and A. T. Everham, president of Midwestern Contractors of Ohio.



XUM

# *Another Year of*
# Pipeline Progress

***Over 560 miles of "Big Inch" construction completed on schedule in 1953 by H. C. Price Co.***

**70 miles**

**TENNESSEE GAS TRANSMISSION**

Seventy miles of 24-inch, extending northeastward from a point near Mercer, Pennsylvania, to add an important link to TGT's expanding pipeline system.

**43 miles**

**TEXAS GAS TRANSMISSION**

Forty-three miles of 26-inch loop lines – one 25 miles long near Owensboro, Kentucky and another 18 miles near Louisville – last phase of an extensive looping project undertaken by Texas Gas.

**185 miles**

**SOUTHERN NATURAL GAS COMPANY**

Five loops, totaling 185 miles of 24-inch, laid in Mississippi, Alabama and Georgia as part of a major construction program nearing completion by Southern Natural.

**266 miles**

**GULF INTERSTATE GAS COMPANY**

More than 266 miles of 30-inch main line, starting near Gordonsburg, Tennessee and extending in northeasterly direction across Tennessee and Kentucky – Northern section of an important new gas artery to the East.

**total 564 miles**

PIPELINE CONSTRUCTORS

H. C. **PRICE** CO

BARTLESVILLE, OKLAHO

*America's Foremost Pipeline Constructor*

XUM

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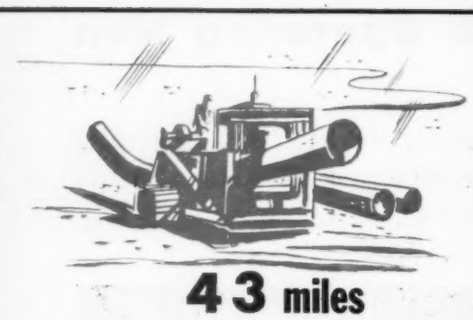

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PIPELINE
H. C. **PRICE** CO
CONSTRUCTORS

BARTLESVILLE, OKLAHO

*America's Foremost Pipeline Constructo*

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# PIPE LINE DEVELOPMENTS

| Name of Company | Miles | Pipe size, in. | Location | Contractor |
|---|---|---|---|---|
| **CRUDE LINES** | | | | |
| California-Oregon Pipe Line System | 103 | 6 | Crescent City, California to Medford, Oregon. | Proposed |
| Cities Service Pipe Line | 60 | 12 | Houston to Sour Lake, Texas. | Planned |
| Gulf Refining | 55 | 12 | Bay Marchand to Plaquemines, Louisiana. | Planned |
| Interprovincial Pipe Line Co. | 129 | 24 | Edmonton to Alberta-Saskatchewan Border | Mannix, Ltd. |
| Interprovincial Pipe Line Co. | 124 | 24 | Alberta-Saskatchewan Border to South Saskatchewan River | Fulton-Banister Construction Company |
| Interprovincial Pipe Line Co. | 201 | 24 | South Saskatchewan River to Gretna, Manitoba. | Anderson International Constructors |
| Lakehead Pipe Line Co. | 153 | 26 | Loops on present line | R. H. Fulton& Company |
| Lakehead Pipe Line Co. | 51 | 26 | Loops on present line | Anderson Brothers |
| Magnolia Pipe Line Co. | 29 | 8 | Midland County, Tex. area | Planned |
| Magnolia Pipe Line Company | 208 | 20 | Corsicana to Beaumont, Texas | Planned, to be built in summer, 1954 |
| Michi, Incorporated | | 10 | Highland, Ind., to Kalamazoo, Alma, and Elsie, Mich. | Planned |
| Mid-Saskatchewan Pipelines, Ltd. | 24 | 8 | Smiley Kerrobert, Saskatchewan, Canada. | Planned |
| NNCW Pipe Line Co. | 127 | 8–10 | Weston County to Casper, Wyoming. | Planned |
| Orchard Pipe Line | 45 | 8 | Orchard to Merino, Colorado. | Proposed |
| Omaha-Denver Express Company | 65 | — | Little Beaverfield to Denver, Colorado | Proposed |
| Pawnee Pipe Line | 35 | 10 | Adena field and Merino, Colorado. | Proposed |
| Powder River Pipe Line Company | 52 | 6–8 | Gathering lines, near Kaysee, Wyoming. | Planned |
| Progress Pacific Pipeline Company | 1100 | 24 | Odessa, Texas, to Los Angeles, Harbor, Cal. | Planned |
| Proven Oil & Refining Company | 32 | 8 | Connection with West Coast Pipe Line to Florence, Ariz. | Planned |
| Roosevelt Oil & Refining Corp. | 22 | 4, 6 | St. Helen to Norwick, Michigan. | Planned |
| Service Pipe Line Company | 55 | 4–6–8 | Tioga-Beaver Lodge area gathering system. | C. P. Bartley & Son |
| Sinclair Pipe Line Company | 10 | 12 | Pauls Valley to Bradshaw Gate Plant, Okla. (Loop). | Planned |
| Sioux Pipe Line System | 1000 | 16 to 24 | Williston Basin to Chicago. | Under consideration |
| Texas New Mexico Pipe Line Company | 52 | 10 | Dawson County to Basin System. | McVean & Barlow |
| Texas Pipe Line Co. | 34 | 6 | Sour Lake to Port Arthur, Tex. | Houston Contracting |
| Texas Pipe Line Co. | 45 | 8–10 | Erath and Bayou Sale sta. | Houston Contracting |
| Trans Mountain Oil Pipe Line Corp. | 26 | 16–20 | Canadian border to Ferndale, Washington. | Planned |
| Trans Mountain Oil Pipe Line Corp. | 27 | 20 | Laurel Junction to Mt. Vernon, Washington. | Planned for 1955 |
| West Coast Pipe Line Company | 960 | 20–22 | Wink, Texas to Norwalk, California. | Planned |
| **PRODUCTS LINES** | | | | |
| American Pipe Line Company | 1910 | 8 to 26 | Beaumont, Tex., to Newark, New Jersey, with laterals. | Proposed |
| Augusta Pipe Line Company | 43 | 8 | Arkansas City to Augusta, Kansas. | Ray L. Smith & Son, Inc. |
| Badger Pipe Line Company | 215 | 8–10–12 | East Chicago, Indiana to Madison, Wisconsin. | Begin Spring '54. |
| Bell Oil & Gas Co. | 150 | 6–8 | Ardmore to Drumright, Okla. | Proposed |
| H. W. Bass & Sons, Incorporated | 152 | 4–6 | Duval and Live Oak Counties, Texas, to Corpus Christi, Texas. | Proposed |
| Great Lakes Pipe Line Company | 130 | | Nebraska City to Grand Island, Nebraska. | Proposed |
| International Pipe Line Inc. | 132 | 8 | Wrenshall to Minneapolis, Minnesota. | Proposed |
| Oklahoma Mississippi River Products Line, | 475 | 12 | West Memphis, Arkansas to White River. | Williams Bros. |
| Oklahoma Mississippi River Products Line, | | | White River to Duncan Oklahoma. | River Construction Co. |
| Phillips Petroleum Company | 54 | 6 | Goldsmith to Borger, Texas. | Planned |
| | 52 | 10 | Shell's Brookshire system to Sweeney, Texas. | Planned |
| Salt Lake Pipe Line Company | 40 | 6 | Adams, Oregon, to Pasco, Washington (Loop). | Planned |
| Shamrock Oil & Gas Corporation | 55 | 6 | McKee to Amarillo, Texas. | Planned |
| Triangle Pipe Line Company | 560 | 12 | Arkansas City, Arkansas, to Covington, Kentucky, and Nashville, Tennessee. | Proposed |
| United States and Canadian Government | 600 | 8 | Haines to Fairbanks, Alaska. | Underway |
| United States Pipe Line Company | 1799 | 22–26 | Beaumont, Texas to Newark, New Jersey. | Proposed |
| Williston Basin Pipe Line Company | 244 | 8 | Laurel-Billings, Montana refineries to Glendive, Mont. | Proposed |
| Wyoming-Nebraska Pipeline Company | 215 | 6 | Cheyenne, Wyoming, to North Platte, Nebraska. | Engineering underway |
| Yellowstone Pipe Line Company | 540 | 10 | Billings, Mont., to Spokane, Wash. (Continental Oil Co., Interstate Oil Pipe Line Co., Union Oil Co., and H. Earl Clack interest). | To be completed 9–54. |
| Yellowstone Pipe Line Company | | | Billings to Bozeman, Montana. | Ross and Powers |
| Yellowstone Pipe Line Company | | | Bozeman to Helena and on to Clinton, Montana. | Associated Pipe Line Contractors, Inc. |
| Yellowstone Pipe Line Company | | | Clinton to Perma, Montana. | Associated Pipe Line Contractors, Inc. |
| Yellowstone Pipe Line Company | | | Clinton to Perma, Montana. | Eastern Pipe Line Fields Service Co. |
| Yellowstone Pipe Line Company | | | Perma, Montana, to Murray, Idaho. | Eastern Pipe Line Field Service Co. |
| Yellowstone Pipe Line Company | | | Murray, Idaho to Spokane, Washington. | Engineers Limited Pipe Line Company. |
| **GAS LINES** | | | | |
| American-Louisiana Pipe Line Company | 1000 | 30 | Lowry, Louisiana to Detroit, Michigan. | Proposed |
| Arkansas-Louisiana Gas Company | 107 | 8⅝ to 24 | Nine Loops on System. | Planned |
| Arkansas-Missouri Power Company | 140 | 2 to 10 | St. Francis River, Clay County, Ark. to near Campbell, Missouri. | Planned |
| Associated Natural Gas Company | 88 | | Missouri. | Proposed |
| Atlantic Seaboard Corporation | 29 | 26 | Looping along Cobb-Rockville, Maryland, line. | Pipe Line Construction & Drilling Company |
| Chicago District Pipe Line Company | 31 | 20–30 | Chicago area. | Proposed |
| Cities Service Gas Company | 18 | 16 | Lawrence and Newton Counties, Missouri. | |
| Cities Service Gas Company | 69 | 20–16 | Cleveland, McClain and Garvin Counties, Okla. | Planned |
| City of Fayette, Alabama | 20 | 5 | Fayette, Ala. to Southern Natural's system in Tuscaloosa County, Alabama. | Proposed |
| City of Dallas, Georgia | | 8, 4½ | Distribution system. | Engineering-Construction Company, 1954. |
| Coast Counties Gas & Electric Company | 40 | 3, 4, & 8 | Coast and Valley Region, California. | Planned |
| Colorado Interstate Gas Company | 365 | 22 | Green River, Wyoming to Denver, Colorado. | Planned |
| Colorado Interstate Gas Company | 243 | 4 to 20 | Colorado, Oklahoma, Texas, and Kansas. | Engineering-Construction and Z. J. Graham |
| Colorado-Western Pipeline Company | 454 | — | S. W. Colorado fields to Denver area. | Planned |
| Colorado-Western Pipeline Co. | 328 | 16–18 | Ignacio field to Pueblo and Denver | Proposed |
| Continental Oil Company, (Agent) | — | — | Gas gathering system in Washington and Adams counties, Colorado. | Planned by operators of Little Beaver and Badger Creek fields |
| Cumberland and Allegheny Gas Co. | 31 | 12 | Garrett County, Maryland, to Keyser, West Virginia. | Proposed |
| El Paso Natural Gas Company | 32.5 | 10 | Reagan county to Upton County, Texas. | Planned |
| Fort Worth Basin Gas Company | — | — | Novice, through Brown and Comanche Counties, Tex. | Planned |
| Glacier Gas Company | 285 | 20 | Kalispell, Montana, to Spokane, Washington. | Proposed |
| Glacier Gas Company | 120 | 16 | Spokane to Hansford, Wash. | Proposed |
| Glacier Gas Company | 91 | 8⅝ | Spokane to Lewiston, Idaho. | Proposed |
| Glacier Gas Company | 130 | 12¾ | Spokane to International boundary at Trail, British Columbia. | Proposed |
| Gulf Interstate Gas Company | 860 | 30 | Acadia Parish, Louisiana, to Boyd County, Kentucky. | H. C. Price and Houston Contracting. 11–54 |
| Gulf Interstate Gas Company | 230 | | Gathering lines. | Associated Pipe Line Contractors. Anderson Bros., Williams Bros. |
| Gulf Interstate Gas Company | 329 | 12–24 | Laterals off Acadia Parish, Louisiana, to Boyd County, Kentucky, line. | Proposed |
| Home Gas Company | 32 | 12 | Breesport to Union Center, New York. | Planned |
| Home Gas Company | 22 | 12–16 | Binghampton, New York. | Under way |
| Houston Texas Gas and Oil Co. | 1600 | 30 | East Texas to Minnesota. | Proposed |
| Houston Texas Gas and Oil Co. | 1600 | 30 | South Louisiana to New York. | Proposed |
| Interstate Power Company | 26 | 8 | From National Gas Pipe Line Co. of America, line near Hooppole, Illinois to Clinton, Iowa | Proposed |
| Iroquois Gas Corp. | 24½ | 20 | Erie County, New York | Proposed |
| Kansas-Nebraska Natural Gas | 41 | 10 | Albion, Arcadia, and Broken Bow, Nebraska. | Proposed |
| Lone Star Gas | 100 | | Proposed storage fields to Dallas-Ft. Worth area. | Proposed |
| Lone Star Gas | 35 | 12 | Southeastern Schleicher County. | Proposed |
| Lone Star Gas | 36 | 12 | Stamford to Abilene, Tex. | Planned |
| Lone Star Gas | 44 | 12 | Red Springs, Woods County to Sulphur Springs area, Hopkins County, Texas. | Under way |
| Manufacturers Gas Light & Heat | 40 | | Allegheny, Washington, and Beaver Counties, Pa. | Proposed |
| Manufacturers Gas Light & Heat | 213 | 3 to 16 | Various points on system in Pa., West Vir. and Ohio. | Proposed |
| Manufacturers Gas Light & Heat | 72 | 16–20 | Doddridge, Wetzel and Marshall Counties, West Vir. | Proposed |
| Michigan Consolidated Gas Company | 25.5 | 12 | Sparta to Muskegon, Michigan. | Planned |
| Michigan-Wisconsin Pipe Line Company | 252 | 4–24 | Loops and stations in Illinois. | Planned |
| Mississippi River Fuel Corporation | 190 | 10–18 | Laterals in Woodlawn and Waskom gas fields, Tex. | Planned |
| Missouri Central Gas | 25 | 6 | Moberly to Macon, Mo. | L. R. Young Construction |

# PIPE LINE DEVELOPMENTS

| Name of Company | Miles | Pipe size, in. | Location | Contractor |
|---|---|---|---|---|
| Missouri Public Service | 24 | 10 | New Franklin to Trenton, Missouri. | Proposed |
| Missouri Public Service | 24 | 10 | Johnson County to Clinton, Missouri. | |
| Montana Power | 52 | 16 | Canada-Montana border to Cut Bank, Montana. | Planned |
| Morganfield Natural Gas | 31 | 4-6 | Through Sturgis, Providence. Clay, Diamond, Wheatcroft and Sullivan, Kentucky. | Planned |
| Natural Gas Producer, Inc. | 100 | 12 | Yenter pool to Denver, Colorado. | Planned |
| New River Gas | 50 | | Summers to Monroe counties, West Vir. to Narrows and Dublin, West Vir. | Planned |
| North Dakota Natural Gas Company | 500 | 10-12 | Statewide system in North Dakota. | Planned |
| Northeastern Gas Transmission | 22 | 8 | Upton, Massachusetts to Pawtucket, Rhode Island. | Planned |
| Northern Indiana Fuel & Light | 35 | 8 | Edgerton to Alburn, Indiana. | Planned |
| Northern Natural Gas | 458 | | Kansas, Texas, Oklahoma, and Nebraska, Iowa and Minnesota, to connect with Permian Basin System. | Proposed |
| Northern Natural Gas | 475 | | Proposed branch lines to Iowa, Neb., Minn. and and South Dakota. | |
| Northwest Alabama Gas District | 40 | 9 | Southern Natural's line through Winfield to Haleyville, Alabama. | Certified |
| Northwest Natural Gas Co. | 665 | 18-24 | Northern Idaho and Eastern Washington. | Proposed (Revised plans) |
| Northwest Utilities Ltd. | 42 | — | Bonnie Glen to Edmonton | Planned |
| Ohio Fuel Gas | 31 | 20 | Licking County to Richland County, Ohio. | Planned |
| Ohio Fuel Gas | 22 | 16 | Dayton, Troy, Piqua and Sidney, Ohio. | Planned |
| Ohio Fuel Gas | 23 | 16-20 | Wellington to Elyria, Ohio. | Planned |
| Ohio Fuel Gas | 16 | 20 | Benton Station to Crawford Station. | Planned |
| Ohio Fuel Gas | 18 | 20 | Crawford Station to near Columbus. | |
| Ohio Fuel Gas | 16 | 16 | Berlin to Sandusky, Ohio. | Planned |
| Ohio Fuel Gas | 74 | 3 to 20 | Hocking, Knox, and Ashland counties, Ohio. | Planned |
| Ohio Fuel Gas | 47 | 20 | Benton Township, Hocking County, to Columbus, Ohio. | Planned |
| Ohio Fuel Gas | 61 | | Northern and southwestern Ohio. | Planned |
| Ohio Fuel Gas | 33 | 20 | Jefferson to Seneca, Ohio. | Proposed |
| Ohio Fuel Gas | 69 | 20-24 | Lines to tie in Gulf Interstate line along various points in Lawrence, Jackson, Vinton, Hocking and Fairfield counties, Ohio. | Proposed |
| Pacific Gas & Electric | 50 | 12-16-20 | Fresno to Merced, Cal. | Planned |
| Pacific Gas & Electric | | 20 | Holm to Topock-Milpitas line—Section 2. | |
| Pacific Gas & Electric | | 12 | Section 3—Parallel existing Madera Livingston line, planned. Napa Wye to Shellville, Cotati to Santa Rosa, California. | |
| Pacific Gas & Electric | 129 | 31 | Main-line loops along Topock, Arizona, to Milpitas, California. | Completion date 11-54 Proposed |
| Pacific Northwest Pipeline Corp. | 1466 | | Ignacio, Colorado, to Bellingham, Washington. | Proposed |
| Pacific Northwest Pipeline Corp. | 380 | | Laterals and spurs off mail line to Pocatello, Idaho to Yakima, Washington. | Proposed |
| Permian Basin Pipeline Company | 280 | 16-24-26-30 | West Texas and New Mexico. | R. H. Fulton & Company |
| Rockland Light & Power Company | 22 | 8 | Orangetown to Tompkins Cover, New York. | Proposed |
| Shenandoah Gas Company | 39 | 3-4-8 | Middleton Virginia, to Martinsburg, West Vir. | Proposed |
| South Georgia Natural Gas Company | 339 | 2-12 | Phoenix, Alabama to Tallahassee, Florida. | Planned |
| Southwest Gas Corporation, Limited | 26 | — | From P.G. & E. line to Victorville, California. | Proposed |
| Tennessee Gas Transmission | 243 | 24 | Hebron, Pennsylvania to Greenwich, Connecticut. | Planned |
| Tennessee Gas Transmission | 28 | 30 | White Plains, New York to Newark, New Jersey. | Planned |
| Tennessee Gas Transmission | 571 | 30 | Kinder, Louisiana to Portland, Tennessee. | Approved |
| Tennessee Gas Transmission | 67 | 30 | Loops in Texas and Louisiana. | Approved |
| Tennessee Gas Transmission | 63 | 26 | Loops in Ohio and Pennsylvania. | Approved |
| Tennessee Gas Transmission | 58 | 20 | Louisiana Gulf Coast to Station No. 507 near Kinder, Louisiana. | Approved |
| Tennessee Gas Transmission | 100 | | Laterals In Texas. | |
| Tennessee Gas Transmission | 45 | 20 | Buffalo, New York to the U. S.-Canadian border, Hamburg station near St. Catherines. | Approved |
| Texas Eastern Penn-Jersey Transmission Corporation | 265 | 24 | Oakford storage field to Lambertville, New Jersey. | Planned |
| Texas Gas Transmission Corporation | 48 | 26 | Loops on Memphis-Slaughter line. | Planned |
| Texas Gas Transmission Corporation | 24 | 16 | South Louisiana gas fields. | Planned |
| Transcontinental Gas Pipe Line Corp. | 421 | 30-36 | Loops on Texas-New York main line. | Planned |
| Transcontinental Gas Pipe Line Corp. | 57 | — | Louisiana, Mississippi and Alabama. | Proposed |
| Transcontinental Gas Pipe Line Corp. | 19 | 12 | Vermilion Parish, Louisiana | Proposed |
| Trans-Canada Pipe Lines, Ltd. | 2247 | 14-36 | Alberta area to Toronto, Montreal | Planned |
| Trans-Northwest Gas Inc. | 246 | — | International Boundary to Washington and Idaho. | Proposed |
| Trans-Northwest Gas | 275 | — | Branch lines. | Proposed |
| Union Gas Company of Canada | 180 | — | Dawn Storage field to Hamilton. | Proposed |
| United Gas Fuel, and Central Kentucky Natural Gas | 92 | — | Gulf Interstate system, Boyd County, Kentucky to Putman County, West Virginia. | Proposed |
| United Fuel Gas | 50 | 20-24 | Wood County to Hanham, West Virginia. | Proposed. Spring 1954 |
| United Fuel Gas | 32 | 24 | Near Ripley, West Virginia to Lanham station, Putman County, West Va. | Proposed |
| United Fuel Gas | 60 | 30 | Lanham in Kanawha County, West Va., to Gulf Interstate line. | Proposed |
| United Natural Gas Company | 50 | 12 | Elk County to Jefferson County, Pennsylvania. | Planned |
| Utah Natural Gas Company | 103 | 16-18 | Clear Creek field near, Price to Salt Lake City, Utah. | Proposed |
| Virginia Natural Gas Company | 153 | — | Buckingham to Richmond and Portsmouth, Va. | Proposed |
| Warren Petroleum | 54 | 4-30 | Lea County, New Mexico. | Planned |
| Warren Petroleum | 23 | 3 to 20 | Garvin County, Oklahoma. | Completion date 6-54. |
| Western Pipe Lines | 833 | 24 | Southern Alberta across Canadian prairies, serving intermediate cities. | Planned |

## FOREIGN CRUDE LINES

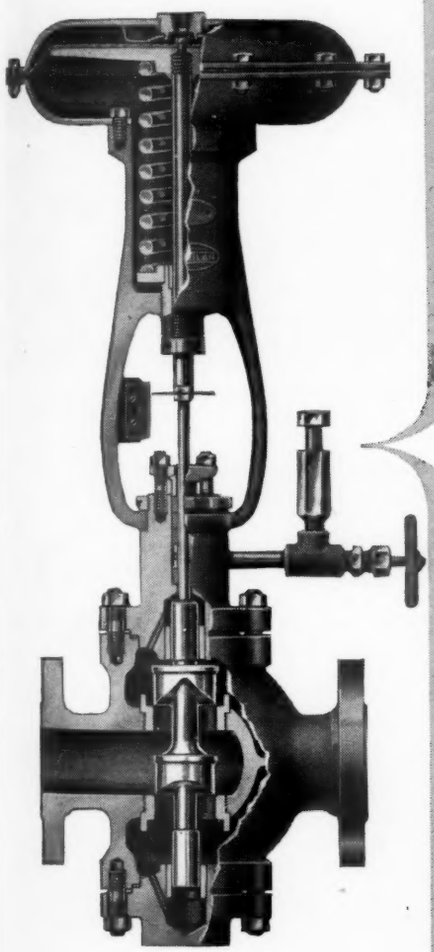
| | | | | |
|---|---|---|---|---|
| Arabian American Oil Company | 18 | 22-20 | Qatif to Ras Tanura No. 3. | Completion date 1-55. |
| Bombay Port Trust | 50 | 8 to 24 | Bombay, India, to serve Standard Vacuum Oil Co. and Burmah Shell refineries. | Merritt, Chapman and Scott Corp. contractors. (Crude and products). |
| Creole Petroleum Corporation | 21 | 34 | Lagunillas to La Salina (State of Zulia, Venezuela) | Williams Brothers Overseas Company |
| Direction General de Yacimientos Petroliferos Fiscales | 409 | | Plaza Huincul to Bahia Blanca, Argentina. | Under way |
| Iraq Petroleum Company | — | 20 | Line diversion from Kirkul-Haifa line to Lebanese coast terminal. | Planned |
| Petroleos Mexicanos | 145 | 12 | 18 de Marzo field via Raynosa to Monterrey, Mexico. | Considered |
| Petroleos Mexicanos | 72 | 12 | Poza Rica to Atzacapotzalco, Mexico. | Proposed |
| Petroleos Mexicanos | 125 | 10 | Jose Colomo to El Plan, Mexico. | Under way |
| Saskatoon Pipe Line, Limited | 56 | 6 | Milden to Saskatoon, Saskachewan, Canada. | Planned |
| Texas Petroleum Co. | 60 | 4-6 | Pta. Nio to La Dorada. | Under way |
| Yacimientos Petroliferos Fiscales Bolivianos | 170 | 4 | Bermejo to Tupiza, Bolivia. | Planned |

## FOREIGN PRODUCT LINES

| | | | | |
|---|---|---|---|---|
| Anglo-Iranian Oil Company, Ltd. | 18½ | 6&16 | Little Aden to Aden. | Bechtel Corporation. |
| Anglo-Iranian Oil Company, Ltd. | 15 | 12 | Kwinana to Fremantle. | M. W. Kellogg Company. Completion date Feb., 1955. |
| Anglo-Iranian Oil Company, Ltd. | 17 | 6 | Kwinana to Fremantle. | M. W. Kellogg Company Completion date Feb., 1955. |
| Columbian Ministry of Petroleum | 115 | 4 | La Dorado to Cartago, Columbia. | Williams Brothers Engineers. |
| Columbian Ministry of Petroleum | 93 | 8 | Cantimplora to Dorado, Columbia. | Williams Brothers Constructors. |
| Empresa Nacional del Petroleo | 30 | 6⅝ | Concon to Santiago, Chile. | Planned |
| Governments of Southern Rhodesia and Portuguese E. Africa | 200 | | Beria, Portuguese Mozamque to Umtalia, Southern Rhodesia. | Considered |
| North Atlantic Treaty Organization (NATO) | 1920 | 4-10 | To serve military bases in Western Europe (to connect with U. S. Government's St Nazaire-Paris Metz line). | Contracted by Soc. Foster Wheeler Francais. |
| Petroleos Mexicanos | 124 | 6 | Lagos to Guadalajara, Mex. | Planned |
| Petroleos Mexicanos | 54 | 6 | Lagos to Aguascalientes, Mexico. | Planned |
| Petroleos Mexicanos | 82 | 8 | Salamanca to Lagos, Mex. | Planned |

## FOREIGN GAS LINES

| | | | | |
|---|---|---|---|---|
| Azienda Generale Italiana Petroli | 90 | 12 | Cortemaggiore to Bologna, Italy. | SNAM crews |
| Azienda Generale Italiana Petroli | 120 | 16 | Cremona Porto Mar to Ghera, Italy. | Montubi, Contractor |
| Azienda Generale Italiana Petroli | 40 | 12 | Rapalta-Bergamo, Italy. | |
| Dirrecion General del Gas del Estado | 310 | 8 | Plaza Huincul to Neuquen, Argentina, to the vicinity of General Conesa, Argentina. | |
| Empresa Nacional del Petroleo | 80 | 10 | Concon to Santiago, Chile. | Planned |
| Northwest Natural Gas Company | 950 | 24 | Alberta fields to Vancouver, British Columbia, Seattle, Washington and Portland, Oregon. | Planned |
| Petroleos Mexicanos | 205 | 16 | Monterrey to Torreon, Mex. | Under way |
| Petroleos Mexicanos | 440 | 20 | Brazil to Tampico to Posa Rice, Mexico. | Planned |
| Sui Gas Transmission Company, Karachi, Pakistan | 350 | 16 | Sui gas field to Karachi, Pakistan. | Planned |



# PLUS VALUES

## Originate and Become "Standard"

## *FIRST*

## in MASONEILAN Control Valves

Within the last decade many extra quality design features in control valves have been originated by Mason-Neilan. Some have been imitated so widely that today they are almost commonplace. Others are available only in Masoneilan Control Valves. All have contributed to improvement in the vital part the valve plays in process control. For example:

**1. SOLID V-PORT VALVE PLUGS:**
Practically eliminate tendency to "spin", once a major limitation with the V-port design. Eliminate squeal or shriek, prevalent with the hollow-skirt design. Improve stability.

**2. FIELD INTERCHANGEABILITY OF PARTS:**
Reduces down-time for service work; eliminates remachining replacement parts to obtain fit. Made possible by rigid uniformity control.

**3. STANDARD 6-30 PSI RANGE:**
(In addition to usual 3-15 psi range) Gives double the power where desirable — available in all sizes *without extra cost.* (Note: All Masoneilan Pneumatic Controllers available with this output range — no extra charge.)

**4. PISTON TYPE VALVE PLUGS:**
Percentage Piston trim makes wide range percentage flow characteristics available in small valve sizes up to 1″.

**5. SPRING STEM KEYLOCK:**
Eliminates plugstem-springstem connection loosening due to torsional stress. Standard on valve sizes 3″ and larger.

**6. BOLTED STUFFING BOX ON ALL SIZES**
of iron and steel valves — provides leak-free seal with minimum friction — gives visual indication of need for repacking or adjustment.

**7. REMOVABILITY OF YOKE WITHOUT DISTURBING STUFFING BOX:**
Facilitates field servicing; large bonnet spud increases strength of connection to yoke.

**8. ENGINEERED REDUCED CAPACITY TRIM:**
Point-4-Factor Trim standardizes sizes; offers only logical solution to reduced capacity trim problem; simplifies selection.

**9. COMPLETE INFORMATION ON SERIAL PLATE:**
Saves time for maintenance men, facilitating service, reducing downtime.

*These examples of progressive design plus built-in accuracy, stamina and economy are tangible reasons why Masoneilan Control Valves are preferred all over the world — wherever quality of product depends on quality of equipment.*

**MASON-NEILAN**
**REGULATOR CO.**
**1182 ADAMS STREET, BOSTON 24, MASS., U. S. A.**

*Sales Offices or Distributors in the Following Cities:* New York • Syracuse • Chicago St. Louis • Tulsa • Philadelphia • Houston • Pittsburgh • Atlanta • Cleveland • Cincinnati Detroit • San Francisco • Boise • Louisville • Salt Lake City • El Paso • Albuquerque Charlotte • Los Angeles • Corpus Christi • Denver • Appleton • Birmingham • New Orleans Odessa • Dallas • Seattle • Mason-Neilan Regulator Co., Ltd., Montreal and Toronto

# PIPE LINE PROGRESS

A string of A. O. Smith line pipe on location during construction of the Interprovincial-Lakehead pipe line.

## 24-inch looping project to increase Interprovincial pipe line crude capacity

**About 135 miles** of 24-inch A. O. Smith line pipe is currently being lowered in to loop Saskatchewan and Manitoba section of 16-inch pipe in the Interprovincial Pipe Line. This will add capacity to a transmission system which, by December, will carry western Canadian crudes from the Edmonton, Alberta, area to Sarnia, Ontario.

**Upon completion,** this will be the world's longest crude oil pipe line, totaling 1738 miles from Redwater to Sarnia.

**All the 20-inch** and 18-inch pipe in the original line, presently terminating at Superior, Wisconsin, is A. O. Smith pipe. The 20-inch main runs from Edmonton to Regina; the 18-inch completes the run from Gretna, Manitoba . . . just north of the U. S. boundary . . . to Superior.

**The present 24-inch** installations are part of extensive looping of the 16-inch sector joining the 20 and 18-inch section.

**Shipments** were made from both Milwaukee and Houston mills, in supplying Interprovincial. A. O. Smith takes pride in its ability to meet delivery schedules, anywhere on this continent, with its high quality, internally expanded, welded line pipe.

*A. O. Smith Line Pipe is available in a complete range of sizes and wall thicknesses, from 8⅝-in. to 36-in. diameters.*

**FIRSTS by A. O. Smith: Welded line pipe • Internally expanded pipe • Light-wall large-diameter pipe • World's largest producer of large-diameter welded steel pipe.**

The A.O. Smith Casing Mill is operating at capacity to supply vitally needed casing for the Oil and Gas Industry.

**A.O.Smith**

**CORPORATION**

**LINE PIPE • CASING**

Chicago 4 • Dallas 2 • Denver 2 • Houston 2
Los Angeles 22 • Midland 5, Texas • New Orleans 12
New York 17 • Pittsburgh 19 • San Francisco 4
Seattle 1 • Tulsa 3 • Washington 6, D.C.

*International Division: Milwaukee 1*

**DEPENDABILITY THROUGH RESEARCH AND ENGINEERING**

# WITH THE PIPE LINE CONTRACTORS

**Barry Construction Company,** 4108 Old Spanish Trail, Houston, Texas, is working on gathering lines for Plains Pipe Line in Wyoming.

**Harris Constructors, Inc.,** Denver, Colorado, is a new Rocky Mountain area firm recently organized that will specialize in pipe line construction. G. R. Rick Harris, Denver investment firm executive, is president of the new firm. Carl H. Breitwieser is vice president and general manager.

**Williams Brothers Company,** 324 National Bank of Tulsa Building, Tulsa, Oklahoma, has contract for 615 miles of 8-in. products line in Alaska for the U. S. Corps of Engineers in a joint venture with McLaughlin, Inc., and Marwell Construction Company.

Company has completed 75 miles of 12-in. line for Oklahoma-Mississippi River Products Pipe Line, Inc., between White River, Arkansas, and Memphis, Tennessee.

Company has contract for 165 miles of 10 through 26-in. lateral lines for Gulf Interstate in Louisiana. O. R. Mitchell is superintendent at Morgan City, Louisiana, field office on one spread, and Red Graves is superintendent on spread two out of Franklin, Louisiana, field office.

Company also has contract for 20 miles of 34-in. line for Creole Petroleum Company in Venezuela. Marvin Jones is superintendent.

**H. B. Zachry Company,** Transit-Tower, San Antonio, Texas, has contract for 208 miles of 20-in. for Magnolia Pipe Line Company between Corsicana and Beaumont, Texas. Work scheduled to get underway soon. About 112 miles of pipe to be used is being coated by C-R-C Engineering Company, Houston, and Mayes Brothers, Inc., Houston.

**G. G. Griffis Construction Company,** 4450 East Admiral Place, Tulsa, Oklahoma, is working on 56 miles of 8-in. crude line for Kaw Pipe Line near Norton, Kansas.

**Dual 16-in. crossing of the Schuylkill River near Conshohocken, Pennsylvania, for Philadelphia Electric Company is being laid by Fulghum Contracting Corporation and inspected by United Engineers and Constructors, Inc. Line is new link is gas transmission lines needed to supply the expanding Delaware Valley area.**

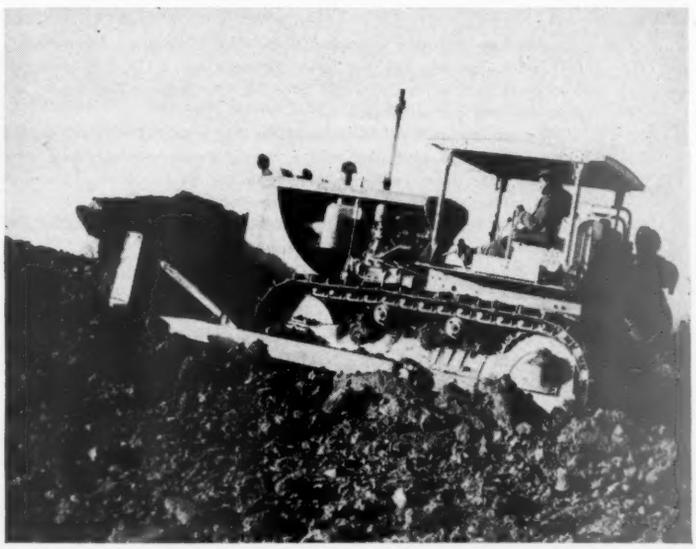
**Pro-Tekto-Cote Corporation,** Box 222, Harvey, Louisiana, is coating and wrapping 73 miles of 2 through 6-in. for City of Dallas, Georgia. Engineering-Construction Company has prime contract. E. O. Vacker is superintendent for Pro-Tekto-Cote.

**Vaughn and Taylor Construction Company, Inc.,** 2103 North Grant, Odessa, Texas, has contract for 100 miles of 2 to 10-in. gas gathering line in Stonewall County, Texas, for Stonewall Gas Products Company.

**Engineering-Construction Company,** 402 North Cheyenne, Tulsa 6, Oklahoma, is working on 24 miles of 4-in. lateral for City of Dallas, Georgia. Curt Vaughan is superintendent; Jimmy Williams, spreadman; and V. L. Bethel, office manager.

Company also has contract for 150 miles of 8 and 10-in. between Phoenix City and Dotham, Alabama, for Southeast Alabama gas district. Job will start later in year.

**Beautiful but rugged is the country where Yellowstone Pipe Line is being built. Scene is near Missoula, Montana, where Eastern Pipe Line is laying 158 of the 10-in. line.**



**New and more powerful tractor just introduced by Caterpillar is this D8, which has several improved engineering and design features including 150 hp, oil clutch, and increased speeds.**



XUM

## Contractors

▸ **Modern Welding Company, Inc.,** Owensboro, Kentucky, has completed city distribution systems in Providence and Fulton, Kentucky. Approximately 20 miles of ¾ to 6-in. in Providence, Wesley Embry, superintendent. Approximately 30 miles, ¾ to 8-in. in Fulton, Wallace Mason, superintendent. Company also has jobs in Martin, Tennessee, and Lexington, North Carolina.

▸ **Midwestern Constructors, Inc.,** 105 North Boulder, Tulsa 3, Oklahoma, is installing pumping, piping and electrical equipment at Forest City, Illinois, for Sinclair Pipe Line Company. Job is 30 per cent complete. Ray M. Johnson is superintendent; Lonnie Dorman, engineer, and W. C. Ryan, office manager.

▸ **United Engineers and Constructors, Inc.,** 1401 Arch Street, Philadelphia, Pennsylvania, has contract for field inspection of dual 16-in. gas line crossing for Philadelphia Electric Company on Schuylkill River near Conshohocken, Pennsylvania. Fulghum Contracting Corporation is prime contractor.

▸ **Williams Pressure Service Company,** 422 Commercial National Bank Building, Shreveport, Louisiana, hydrostatic pipe line testing company, is working on testing of additional gathering lines being added to Wilcox Trend Gathering System, Inc. T. V. McLeod is superintendent at Goliad, Texas. Company's other units are in yard at Shreveport for general overhaul.

▸ **Pipe Line Construction and Drilling Company,** Camp Hill, Pennsylvania, has completed 38 of 80 miles of 16-in. for Sinclair between Camden and Linden, New Jersey. Company also has 42 miles of 26-in. for Seaboard in Maryland and Virginia, no starting date announced. R. B. O'Neal, Meril Fandray, Lee Ross, and Curt Steepleton are superintendents.

▸ **Mid-States Construction Company,** Box 417, Mt. Vernon, Illinois, has 32 miles of ¾ through 6-in. gas transmission and distribution system in Huntington, Indiana. E. C. Veach is in charge of work, H. W. Randall, superintendent, and Sam Wilson, office manager.

▸ **Anderson International Contractors,** Edmonton, Alberta, has contract for 201 miles of 24-in. loop for Interprovincial Pipe Line Company in two sections, including one section of 101 miles between east bank of South Saskatchewan River and Regina, and another 100 miles between Regina, Saskatchewan, and Gretna, Manitoba. Whitey Gould is superintendent of spread work on 101 mile section, out of Regina field office, and Buster Watson is superintendent of other spread with headquarters in Gretna. R. W. Dick Jernigan will be in charge of over-all project.

▸ **Fulton Banister Construction Company,** Edmonton, Alberta, is working on 124 miles of 24-in. loop for Interprovincial Pipe Line between Alberta-Saskatchewan border and west bank of South Saskatchewan River. Jack Flavin is engineer in charge at the Rosetown, Saskatchewan, field office.

▸ **Mannix, Ltd.,** Calgary, Alberta, is working on 129 miles of 24-in. loop for Interprovincial Pipe Line between Edmonton and Alberta-Saskatchewan border.

▸ **R. H. Fulton and Company,** P. O. Box 1526, Lubbock, Texas, has contract for 133 miles of 26-in. loop line for Lakehead Pipe Line Company in two sections, one 75 miles and the other 58 miles.

▸ **Anderson Brothers Corporation,** P. O. Box 2591, Houston, Texas, is working on approximately 70 miles of 3, 4, 12, and 24-in. natural gas line for Gulf Interstate Gas Company in Louisiana. Dick Leonard is superintendent, with headquarters at Abbeville, Louisiana.

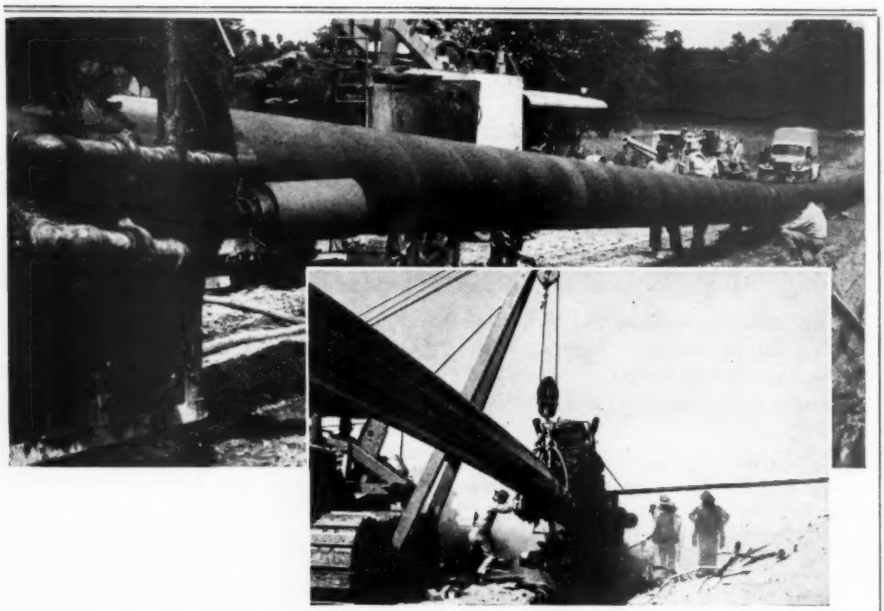
Company also has contract for 51 miles of 26-in. loop for Lakehead Pipe Line. Work will begin when weather and ground condition permits.

▸ **Associated Pipe Line Contractors, Inc.,** Houston, Texas, is working on 175 miles of 10-in. line from Bozeman, Montana, to Clinton, Montana, for Yellowstone Pipe Line Company. Jim Ed Andrews is superintendent and Buck Johnson office manager at the Bozeman field office.

▸ **Foster Wheeler Corporation,** 165 Broadway, New York 6, New York, has contract with North Atlantic Treaty Organization for management of 1920 miles of product line to be laid in Western Europe.

▸ **Collins Construction Company,** Victoria, Texas, has contracted from Merritt-Chapman and Scott of India for construction of 84,000 ft of submarine line in the harbor at Bombay, India.

Company has completed approximately 2.2 miles of underwater crossing for Socony-Vacuum at Accra, West Africa in joint venture with Taylor-Woodrow, Ltd., West Africa.

# Mile after mile – to last for years

This line is being wrapped with RUBEROID pipe line asbestos felt over PITT-CHEM. hot applied tar base coating. An S. D. Day man was on hand when these jobs were started to give his help and advice — part of the follow-up service you get when you "DEAL WITH DAY."

The ability of RUBEROID asbestos felt and PITT-CHEM. coal tar enamels to meet and withstand the severe requirements of pipe line service against corrosion adds years to the useful life of pipelines. Both of these products are stocked in Houston for immediate shipment.

Engineering counsel, literature and prices are furnished through our Houston office.

S. D. Day Company is National Distributor for The Ruberoid Company pipe line asbestos felt, and Gulf Coast Distributor for Pittsburgh Coke & Chemical Co. hot and cold applied coal tar coatings, and American Coating & Supply Company's fieldjointer.

*The Pipeliner's Friend says,*
*"Formula 291 gives skin protection for those working where fumes may be toxic."*

S. D. DAY COMPANY

1973 WEST GRAY HOUSTON, TEXAS PHONE JU-2431

## Contractors

**Z. J. Graham,** Box 1203, Amarillo, Texas, has 9 miles of 24-in. lay for J. M. Huber Corporation, Borger, Texas, and 12 miles of 12, 16, and 18-in. take up. R. W. Miller is superintendent.

Company also has 8 miles of 16-in. near Amarillo for Pioneer Natural Gas Company. Job to start in near future.

**Engineers Limited Pipeline Company,** 225 Bush Street, San Francisco, California has 109 miles of 34-in. line for Pacific Gas and Electric in two loops, one 79 mile section between Newberry and Danby, California, and a 30-mile section from San Martin to Tres Pinos, California.

Company also has 81 miles of 10-in. line for Yellowstone Pipe Line Company between Murray, Idaho, and Spokane, Washington. C. P. Hamilton is superintendent and Virgil Darby, office manager.

J. B. Sheehan

### John B. Sheehan, Pioneer Pipe Line Contractor, Dies

John B. Sheehan, general manager of the Sheehan Pipe Line Construction Company, Tulsa, Oklahoma, one of the pioneer pipe line contractors, died March 10.

Sheehan was hospitalized March 1, two days after returning to Tulsa from St. Petersburg, Florida, where he became ill while on vacation. He had suffered from diabetes for many years.

Sheehan attended public and parochial schools in Bradford, Pennsylvania. Before going to Tulsa he was in the general contracting and brick manufacturing business at Bradford, was an oil driller in Sisterville, West Virginia, and a pipe line constructor at Independence, Kansas. He assisted in organizing the pipe line contracting firm in Tulsa in 1922 with which he has since been connected.

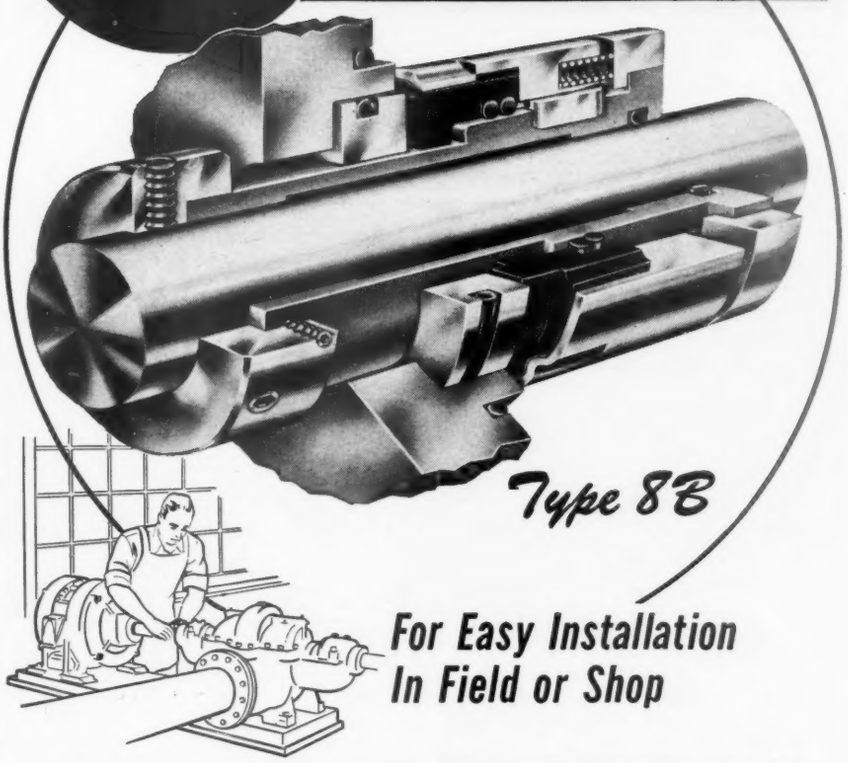
A prominent Catholic, Sheehan was awarded in 1941 the Grand Cross of the Knights of the Holy Sepulchre.

Mr. and Mrs. Sheehan would have observed their fortieth wedding anniversary April 22.

Also surviving are two sons, Robert D. Sheehan and Thomas J. Sheehan, of Tulsa; three daughters, Gertrude E. and Josephine Anne Sheehan, of the home, and Mrs. Helen Marie Corcoran, Tulsa; four sisters, Rosemary, Kathleen, and Helen Sheehan and Mrs. Elizabeth Horrigan, all of Tulsa, and five grandchildren.


JOHN CRANE

PACKAGED TYPE MECHANICAL SEALS FOR High Pressure Pipe Line Pumps




For Easy Installation In Field or Shop

Manufacturers of large centrifugal pumps and pipe line operating engineers have long been asking for an end face mechanical seal meeting these requirements: 1) heavy-duty design to handle high pressure applications; 2) single-unit packaged construction for easy installation; 3) a full range of sizes to meet individual specifications.

*"John Crane" has met this need with the Type 8B hydraulically balanced seals for pressures to 1200 psi.*

These seals can be quickly installed and adjusted simply by sliding the entire unit along the shaft into final position. Removal of the top casing is not necessary. This feature alone results in the saving of many man-hours of maintenance work.

Field reports and performance records point to the steadily increasing use of "John Crane" high pressure seals to eliminate problems connected with the handling of hydrocarbons, crudes, gasoline and other petroleum products.

To help you in your individual requirements, "John Crane" offers nationwide service—available without obligation from strategically located factory owned branch offices.

Write for illustrated high pressure seal bulletin.

Crane Packing Co., 1843 Cuyler Avenue, Chicago 13, Illinois.

*In Canada:* Crane Packing Co., Ltd., 617 Parkdale Ave., N., Hamilton, Ont.

JOHN CRANE CRANE PACKING COMPANY

## Contractors

**Holdren Construction Company,** Box 417, Mt. Vernon, Illinois, is working on 25 miles of ¾ through 4-in. transmission and distribution system in Jasper, Indiana, on sub-contract from Mid-States Construction Company. E. C. Veach is general superintendent, H. W. Randall, superintendent, and Sam C. Wilson, office manager.

Company also has 67 miles of ¾ through 6-in. yard coating job on sub-contract from Mid-States. L. A. Hudson is foreman.

**Dunn Brothers,** 801 Mercantile Building, Dallas, Texas, has reported the following hauling, stringing and unloading jobs:

335 miles of 30-in. for Gulf Interstate Gas Company between Kinkade, Tennessee, and Kenova, West Virginia. Prime contractor is H. C. Price Company.

140 miles of 30-in. for Tennessee Gas Transmission Company between Savannah, Tennessee, and the Tennessee-Kentucky state line.

62 miles of 30-in. for Tennessee Gas Transmission Company between Lisbon and Cambridge, Ohio.

Various sizes for El Paso Natural Gas Company in the Farmington, New Mexico, area. El Paso is doing own construction.

208 miles of 20-in. for Magnolia Pipe Line Company, Corsicana to Beaumont, Texas. Prime contractor is H. B. Zachry Company.

49 miles of 12-in. for El Paso Natural Gas Company, Farmington, New Mexico, to Rankin, Texas.

**Eastern Pipe Line Contractors,** 1801 Mercantile Bank Building, Dallas, Texas, has completed one of two sections of the Yellowstone Pipe Line System between Billings, Montana, and Spokane, Washington. Eastern has 82 miles left of 158 miles of the 10-in. line. Spread working east out of Murray, Idaho. A. L. "Bull" Stewart is superintendent and J. W. Arthur, office manager.

**Panama-Williams Company,** Melrose Building, Houston, Texas, has 138 miles of 8 and 10-in. takeup between Dobbin and Concord, Texas, for Texas Pipe Line Company.

**Parkhill Truck Company,** P. O. Box 1856, Tulsa, Oklahoma, reports the following work:

Hauling 30-in. pipe for Gulf Interstate Gas Company from Houston and Orange, Texas, to storage points in eastern Louisiana and Mississippi.

Hauling, storing where necessary, and stringing approximately 303 miles of 12-in. pipe from White River to Allen, Oklahoma, for Sunray Oil Corporation. Contractor, River Construction Corporation. Also approximately 97 miles of 10-in. pipe from Allen, Oklahoma, to Duncan, Oklahoma.

Unloading, hauling and stringing approximately 70 miles of 3, 4, 12, 20, and 24-in. pipe for Gulf Interstate gathering system in Louisiana. Contractor is Associated Pipe Line Contractors, Inc.

Hauling, unloading and racking approximately 50 miles of 24-in. for Texas Eastern Jenn-Jersey from mill at Claymont, Delaware, to points in New Jersey and Pennsylvania.

**H. C. Price Co., Pipeline Division,** P. O. Box 1111, Bartlesville, Oklahoma, has the general contract covering construction of approximately 355 miles of 30-in. high pressure natural gas pipe line for Gulf Interstate Gas Company starting at a point near Gordonsburg, Tennessee, and extending northeasterly to a point near Catlettsburg, Kentucky. Approximately 75 miles remaining to be completed. Work will begin soon as weather and ground conditions permit.

**Houston Contracting Company, Ltd.,** 2707 Ferndale Place, Houston, Texas, has the following construction work:

Approximately 500 miles of 30-in. natural gas line for Gulf Interstate Gas Company from Rayne, Louisiana, to Kinkade, Tennessee. 370 miles have been completed and the remaining 130 miles will be handled as follows:

From New Albany, Mississippi, going north, E. C. Norris, superintendent; R. E. Thornton, assistant superintendent; R. J. Axsom, office manager; headquarters, New Albany, Mississippi. Work to start as soon as weather and ground conditions permit.

From Kinkade, Tennessee, going south, M. L. Thompson, superintendent; J. B. Stoddard, office manager; headquarters Hohenwald, Tennessee. Work to start as soon as weather and ground conditions permit. Superintendent W. H. Hayes is expected to be back to work soon.

Approximately 65 miles of 12-in. products line for Shell Pipe Line Corporation from Baton Rouge, Louisiana, to Norco refinery near New Orleans. Personnel is not yet selected. Work to start in early April depending upon weather and ground conditions.

As Conforming as a Kiss
FRANK WHEATLEY'S
SYNTHETIC RUBBER SEAL
A FULL PIPE OPENING HORIZONTAL SWING CHECK VALVE
Sizes: 2" to 24"
Pressures: 125# WP to 1800# WP
Ends: Flanges, Screwed, weld
Steel · Iron · Bronze · Aluminum
Equipped with Wheatley Synthetic Seal—a synthetic rubber ring dovetailed and fitted into a removable bronze seat, also dovetailed to accept this rubber ring. When the bronze clapper falls against this rubber, a perfect seal is formed regardless of what irregularities have deposited on the seat or in the fluid, such as sand, scale and cutting which under pressure ordinarily would completely cut out a hard-surfaced seat.
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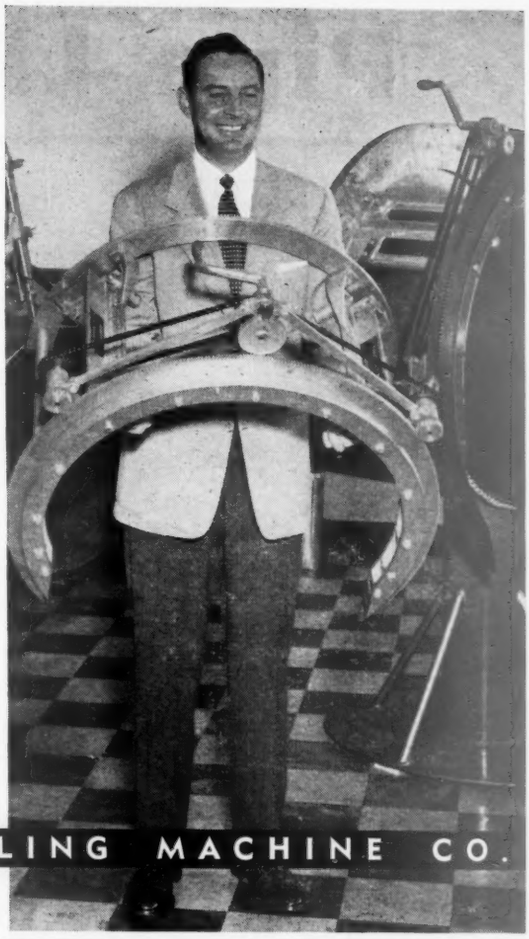
# H & M PIPE CUTTING AND BEVELING MACHINES NOW 40% LIGHTER!



## HERE IS THE AMAZING STORY...

A completely new manufacturing process has made it possible to drastically reduce the weight of the renowned H & M Pipe Cutting and Beveling Machine. The search for a light, tough metal was started many months ago in an attempt to make the H & M line the lightest in its class without destroying any of its famous accuracy, long life, or economy. After months of searching, a satisfactory process was finally encountered. The H & M test model was rigged to an electric motor and the torch arm automatically sent around the pipe over 25,000 times. During the test, sand and other abrasive materials were blown into the highly machined gears, and the machine exposed to a multitude of simulated weather conditions. A micrometer check following this torturous test showed NO WEAR ON THE GEARS.

Here are the amazing new weights of the H & M Pipe Cutting and Beveling Machine: #3 machine — 14" to 20" pipe formerly 89½ lbs now 53 lbs.; #4 machine — 22" to 26" pipe formerly 123 lbs. now 66 lbs.; #5 machine — 28" to 36" pipe formerly 155 lbs. now 95 lbs. (all weights are approximate).

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Lightest in its Class!

H&M PIPE BEVELING MACHINE CO.

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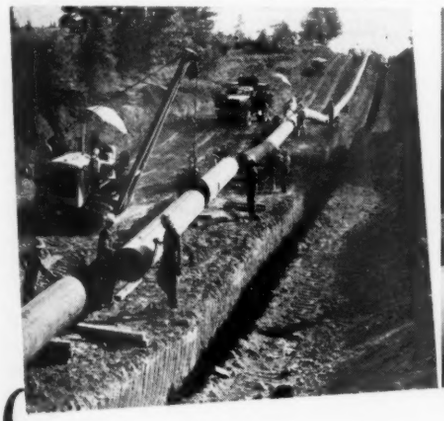

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*Oil - Gas - Gasoline - Water Pipe Lines*

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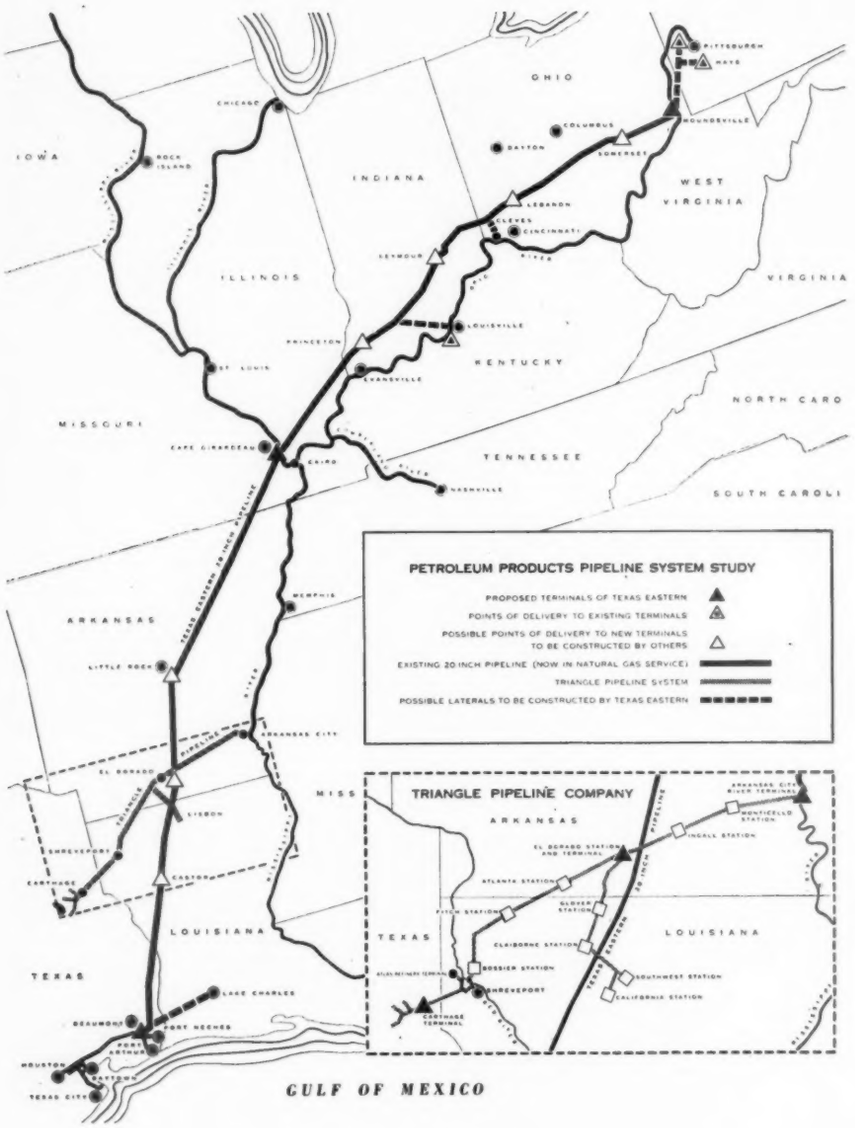
# Pipe Line Projects




## Little Big Inch Reconversion Plans Indefinite; Must Await New Gas Construction, Legal Approval

George T. Naff, president of Texas Eastern, commenting on the proposed reconversion of the Little Big Inch pipe line from natural gas to petroleum products service, has stressed that no reconversion is contemplated without first accomplishing such additional construction as is necessary to insure maintenance of at least the company's present natural gas capacity. He said that the reconversion of the present 20-in. line is based on the assumption that the legal matters and other related problems can be resolved and that the Federal Power Commission will enter an order permitting the abandonment of natural gas service through certain portions of the 20-inch line and the substitution of other facilities for such service.

Studies conducted by Texas Eastern, he said, have indicated that the conversion of the Little Inch line as far east as Moundsville, West Virginia, is feasible. "Based on long range economic considerations we believe that the reconversion project will prove of material benefit not only to the public and the holders of the company's securities, but also to the nation from the standpoint of national security," Naff said.

He estimated that the minimum construction required to reconvert the 20-inch line to the transportation of oil products as far east as the Pittsburgh area and to provide substitute facilities to replace the 20-in. line capacity would require an expenditure of approximately $76,000,000. The company may construct substitute facilities with a capacity in excess of that of the present 20-in. system in order to provide for further expansion in the future.

He added that details of the exact manner in which the alterations to the natural gas system would be made have not been completed but are at present being engineered and that Texas Eastern is completing studies on the subject preparatory to filing the necessary applications with the Federal Power Commission.

## Army Hydraulic Tables Handbook Re-Issued

"Hydraulic Tables," a pocket-size handbook prepared under direction of the Chief of Engineers, U. S. Army, has been reprinted by the Government Printing Office, and is now available at $2.50 a copy.

The 565-page handbook, originally published in 1944 and for some time out of print, is in wide demand by hydraulic engineers, engineering colleges, and various Government agencies.

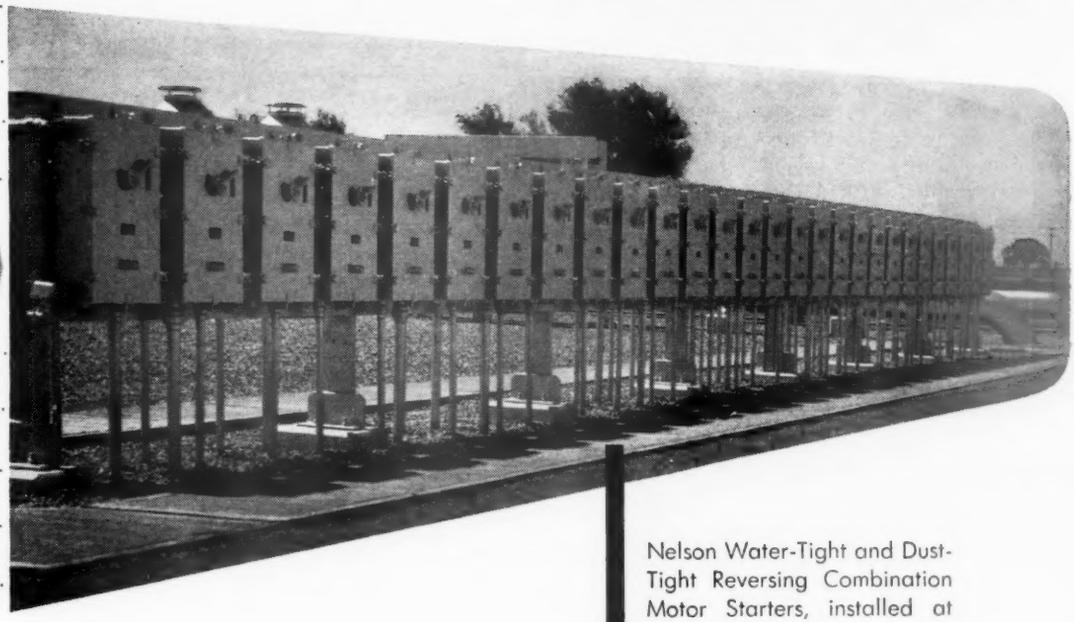
The book contains 46 tables, including extensions of tables in King's "Handbook of Hydraulics," the Bureau of Reclamation's "Hydraulic and Excavation Tables," and some new tables.

## FPC Approves Expansion Program Completion

The Federal Power Commission has authorized Northern Natural Gas Company, Omaha, Nebraska, to complete a proposed expansion of its pipe line system, already started, to enable it to deliver additional natural gas to existing customers and to supply several new customers in the Midwest commencing next winter.

The newly-authorized facilities include approximately 204 miles of main line pipe and 22,800 horsepower in main line compressor additions. The cost is estimated at $23,776,000. Additional branch lines authorized for new service will cost an estimated $14,689,057.

The project is the final phase of an expansion program which will increase Northern's total system capacity by approximately 300 million cubic feet daily. The additional gas is being received in Texas from Permian Basin Pipeline Company.



Nelson Water-Tight and Dust-Tight Reversing Combination Motor Starters, installed at pipe line station of major pipe line company.

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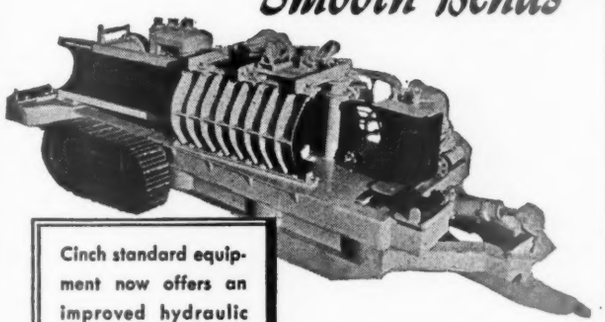

Cinch standard equipment now offers an improved hydraulic system and new wedge-type pin-up slide for greater durability and speed. If desired, even faster, easier maneuvering can be obtained with Athey tracks and hydraulic lift tongue.

Contractors swear by Cinch "Smooth Bend" Pipe Benders for dependability and uninterrupted service. Cinch Pipeline Equipment provides the most up-to-date equipment and expert maintenance.

PIPE BENDERS LINE-UP CLAMPS

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## Montreal AGA Conference To Cover Vehicles, Corrosion

An intensive program covering nearly every phase of the distribution, motor vehicles and corrosion branches of the gas utility and pipe line industry will be presented by the Operating Section of the American Gas Association at a four-day conference to be staged at the Mount Royal Hotel, Montreal, Canada, April 20 through 23. Nearly 1,100 representatives of gas companies in the United States and Canada are expected to attend the meeting.

Delegates will be welcomed at the opening session on April 20 by P. W. Geldard, The Consumers' Gas Company, Toronto, as chairman of the A.G.A. Distribution Committee. The Honorable Camille Houde, Mayor of the City of Montreal will greet the delegates after an introduction by Raymond Latreille, Commissioner, Quebec Hydro-Electric Commission. Latreille is immediate past-president of the Canadian Gas Association.

Robb Quinby, The Brookly Union Gas Company, will discuss the financial needs of the gas industry. He is an outstanding rate expert and will bring a valued viewpoint to the conference. James Webb, Consolidated Edison Company of New York will offer a new approach to meter design, with an open discussion on metering.

Dual luncheon conferences will be held Tuesday noon, with K. W. Person, Minneapolis Gas Company, presiding at a meeting devoted to construction and maintenance and J. M. Chrisman, The East Ohio Gas Company, Cleveland, as chairman of the conference on meters and metering.

## FPC Okays Exchange of Gas Company Facilities

FPC has approved an application by Fort Smith Gas Corporation to acquire certain of the natural gas facilities of Arkansas-Oklahoma Gas Company, and concurrently granted an application by Arkansas-Oklahoma for authority to sell and transfer its facilities to Fort Smith. Both concerns have main offices in Fort Smith, Ark.

Through the transaction, Fort Smith will acquire from Arkansas-Oklahoma 61.2 miles of gathering lines, 236.9 miles of transmission lines, 231.6 miles of distribution mains and 207,000 ft of customers' services. The facilities will be used by Fort Smith to transport and distribute natural gas in Sequoyah and LeFlore counties, Oklahoma, and in Sebastian, Crawford and Franklin counties, Arkansas.

## Merger of Companies To Be Considered

Stockholders of Mississippi River Fuel Corporation and its subsidiary Natural Gas and Oil Corporation will be asked to approve a merger of the two companies, it has been announced. Directors of the two companies, acting on management recommendations, have approved submission to stockholders of a proposed merger agreement. It will be considered by Natural Gas and Oil shareholders at the company's annual meeting May 26, and by Mississippi River Fuel shareholders at their annual meeting May 27. Both meetings will be in St. Louis.

## Carolina Natural Plan Withdrawn, FPC Okays

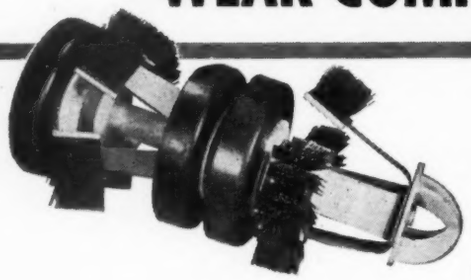
The Federal Power Commission has issued an order allowing Carolina Natural Gas Corporation, Charlotte, North Carolina, to withdraw an application filed in May, 1952, requesting authority to construct about 40 miles of transmission line to supply natural gas to Rock Hill and other markets in South Carolina.

The company filed its request for an order allowing it to withdraw the application. Carolina Natural said that it had been unable to get sufficient financing for the project.


Williamson
PIPELINE PIGS-

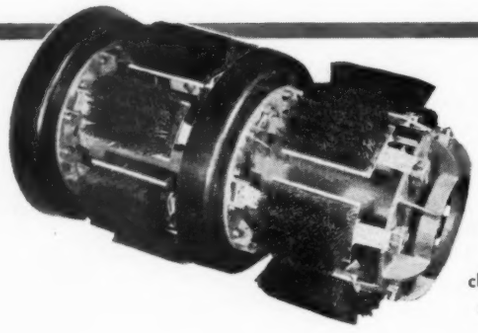
the standard for oil lines because they have

WEAR COMPENSATION



TYPE WCK-11
WILLIAMSON PIG

Sizes 6" to 14" and will traverse 6-foot radius field bends, conventional pipeline gate valves. Springs compensate for brush wear.



TYPE GP-4
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The standard tool for Big-inch oil lines everywhere. Brushes are expanded by arched springs for efficient cleaning . . . Brush and cup have a service life up to 1,000 miles.

Send for descriptive folder showing uses of Williamson Pigs.

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CLEANS PIPE LINES

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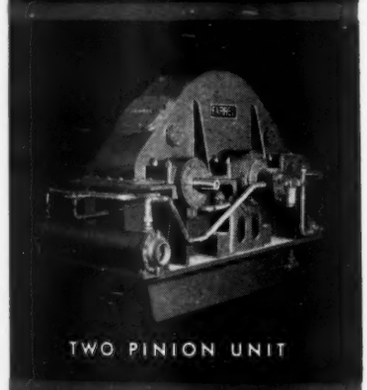
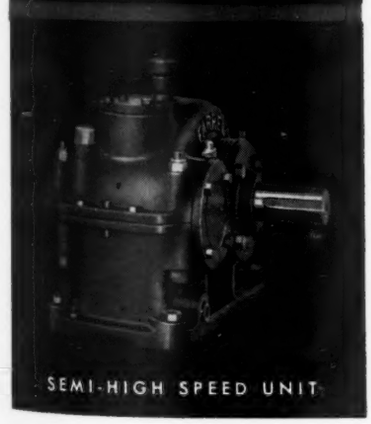
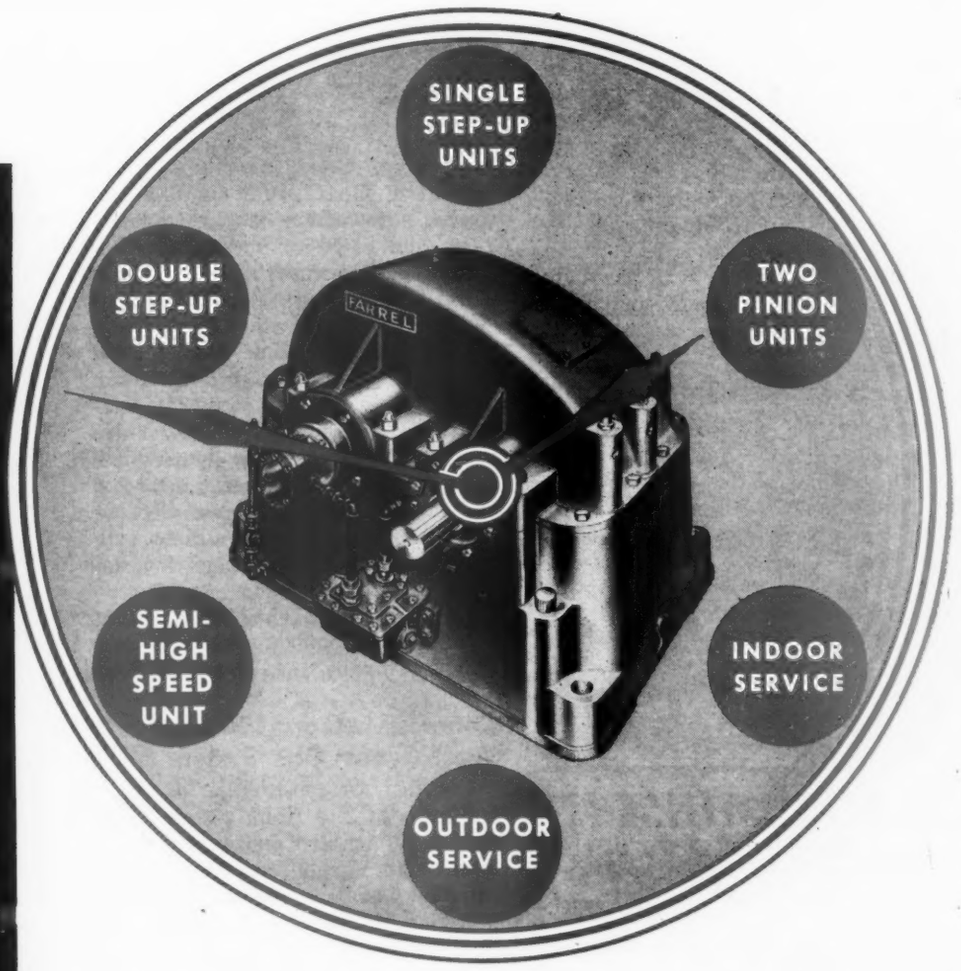
# When it's time to buy SPEED INCREASERS Farrel has the exact unit you need

SINGLE STEP-UP UNIT

DOUBLE STEP-UP UNIT


TWO PINION UNIT


SEMI-HIGH SPEED UNIT




Farrel Type SI units are built in a standard line, consisting of 49 sizes.

Single step-up units have ratios ranging from 1:1 to 12:1. Where higher ratios are required, double step-up units are supplied with ratio range from 12:1 to 40:1.

Two-pinion units, designed to transmit power from a single engine to two pumps are also available.

When requirements fall between the range of Type SI units and standard commercial speed reducers, Farrel semi-high speed units are recommended.

Farrel engineers will be glad to help you select the right gear unit for your high-speed application. Write for further information about any of the types mentioned.

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## Projects

### Northern, Subsidiary Merge Organizations

The FPC has authorized Northern Natural Gas Company to acquire all of the natural gas facilities of its wholly-owned subsidiary, Independent Natural Gas Company of Omaha.

Independent's facilities are located in Gray and Carson counties, Texas, and include an 11,200 hp compressor station and about 21 miles of 20-in. pipe line. The subsidiary transports about 36,000,000 cu ft of gas per day, purchased from Phillips Petroleum Company, for sale to Northern, and also transports for the account of Northern another 10,000,000 cu ft of gas daily that the parent company purchases from Phillips.

### Testing Service Organized For Welder Qualifications

To meet a growing demand for scientific qualification of welders, the Penn Testing Laboratories, Inc., Marietta, Pennsylvania, has organized a new nation-wide testing service designed to protect pipe line contractors and owners from excessive costs resulting from faulty welding.

The firm will qualify welders in accordance with the detailed tests included in the recently-issued American Petroleum Institute Standard 1104 for Field Welding of Pipe Lines.

The company previously had certified welders for Army contracts and is now offering the physical laboratory testing service to pipe line companies and contractors.

### Iroquois Gas Plans Short New York Line

Iroquois Gas Corporation, Buffalo, New York, has filed an application with the FPC requesting authorization for the construction of approximately 24½ miles of 20-in. natural gas transmission pipe line in Erie County, New York.

The proposed new line, estimated to cost $1,540,000, would extend from Iroquois' Porterville compressor station in Elma, New York, to a city gate mixing station in Tonawanda, New York. The application says that the new line would give greater capacity, stability and flexibility to the Iroquois distribution system by providing a direct supply of natural gas at the mixing station in Tonawanda for use both by Iroquois and by its wholesale customer at that point, Republic Light, Heat and Power Company, Inc., also of Buffalo.

### Contract Let on 100-Mile West Texas Gas System

Contract for construction of about 100 miles of 2 to 10-in. gas gathering lines in Stonewall County, Texas, has been let to Vaughn and Taylor Construction Company, Odessa, by Stonewall Gas Products Company, a C. W. Murchison enterprise.

The system will take gas from eight fields in the county and deliver to a processing plant in the Katz field. Throughput capacity will be 12,000,000 cu ft daily, but compressor capacity will limit it to 5,000,000 cu ft daily. Lone Star Gas Company will buy the residue gas.

### API's Moss to Europe As Pollution Adviser

James E. Moss, director of the Division of Transportation of the American Petroleum Institute, has been designated as an adviser-member of the U. S. Delegation which will participate in an international conference on water pollution in London next month. Moss' services were requested by the U. S. State Department.

The conference, to be held April 26, is being sponsored by the British government. Representatives of some 40 nations have been invited to discuss the overall problem of sea pollution.

During World War II, Moss served as a consultant for the Navy and Coast Guard, and has frequently assisted the government on problems of transportation, water pollution, and maritime affairs generally.

### Transco Seeks Approval On Expansion Facilities

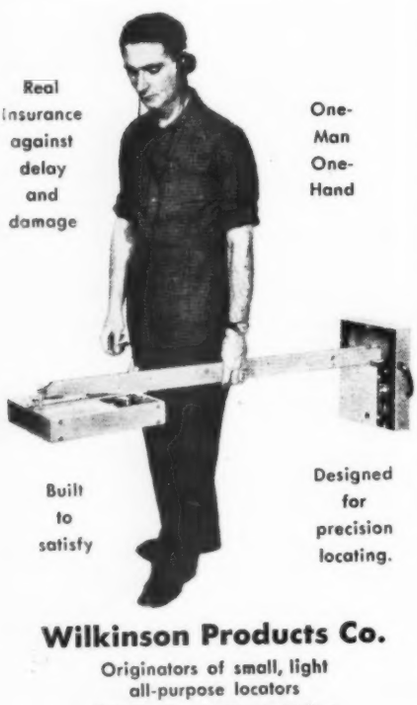
Transcontinental Gas Pipe Line Corporation, has requested authorization for the construction and operation of pipe line facilities to enable it to increase natural gas deliveries to six customers in the New York City-New Jersey area by 93,490,000 cu ft per day.

Transcontinental said that it is seeking authority for substantially the same service as that proposed by Tennessee Gas Transmission Company in another application pending before the FPC.

The proposed expansion project is estimated to cost $53,058,013. The construction would include a total of about 421 miles of loop line and 15,600 horsepower to be installed in new and existing compressor stations. The loops would consist of about 190 miles of 30-in. pipeline and 231 miles of 36-in. pipeline paralleling sections of the company's existing system in Louisiana, Mississippi, Alabama, Georgia, North and South Carolina, Virginia and Maryland.


**THE WILKINSON LINE LOCATOR**

will substitute *facts* for guesses and map errors

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Originators of small, light all-purpose locators

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(Formerly: Pelican Well Tool & Supply Company)

R. E. Nelson, Jr., (right) general manager of crude oil supply and products pipe lines for Standard Oil Company (Indiana), presents accident prevention award to S. L. Jackson, manager of products pipe lines. Plaque was given by the American Petroleum Institute for department's record of 1,120,891 man hours without a disabling injury.

Onlookers are F. L. Hoffmeister (left), superintendent of industrial relations, and O. S. Abbey, general superintendent of operations for the department.

## Line For More Permian Gas Sought by El Paso Natural

El Paso Natural Gas Company has filed an application with the FPC requesting authority to construct pipe line facilities in Lea County, New Mexico, that will enable it to acquire up to 56,000,000 cu ft of additional natural gas per day in the Permian Basin area.

The proposed construction, estimated to cost $3,295,589, would include construction of a total of 13.3 miles of pipe line; 1540 hp in compressor capacity; a purification and dehydration plant to be known as the Monument treating plant; and metering facilities.

## Price To Coat Line For Badger System

H. C. Price Company has been awarded a contract to apply Somastic coating to the entire new products system being built by Badger Pipe Line Company from East Chicago, Indiana, to Madison, Wisconsin.

A railhead coating plant has already been moved to Elmhurst, Illinois, a suburb of Chicago, where processing of pipe will start at an early date. The plant, subsequently, will be relocated at Union, Illinois and South Janesville, Wisconsin. The coating project, one of the largest of its kind recently undertaken, will be under the supervision of Nelson VerSoy. Bill Creel will serve as office manager, while Price foremen will include S. D. Pugh and Burl Witherspoon.

The coating contract calls for a ½-in. application of Somastic to 197 miles of 12¾-in. and 17½ miles of 10¾-in. pipe. Coating for the 12-in. pipe will weigh 19.51 lb per lineal foot and that for the 10-in. pipe will weigh 16.56 lb. An estimated total of 12,000 tons of coating material will be required for the entire project. Completion of the project by mid-summer is anticipated.

The Badger system will be jointly owned and operated by Cities Service Oil Company, Sinclair Pipe Line Company, Pure Oil Company, and the Texas Company. It will be built and operated under Cities Service Pipe Line Company management, with Milo Margenau serving as president and Harry Nelson as manager. The 12-in. products line will have a capacity of 65,000 barrels a day, with distribution points at Madison, Wisconsin; Rockford, DesPlaines and Southwest Chicago, Illinois.

## North Dakota Office Opened by Service

To more closely supervise its growing operations in North Dakota, a new district headquarters has been established here by the Service Pipe Line Company.

The company operates crude oil gathering systems in the Tioga and Beaver Lodge fields of Williams and Mountrail counties, and is connecting wells in McKenzie County. It also operates at partial capacity a trunk system running 154 miles from Tioga to Mandan. This operation will be stepped up when a refinery now under construction at Mandan is completed.

The new district office will be occupied by A. S. Munneke, district superintendent; L. W. Whitney, division engineer; and C. E. Dougherty, division gager. The Tioga office of the company will not be affected as gagers, connection crews and maintenance men will continue to work from there. The new Williston district is part of the company's Wyoming division. R. R. Strand, Casper, is the division manager.

Munneke was named superintendent of Williston district January 1 but is remaining in Casper awhile to supervise the Wyoming division.

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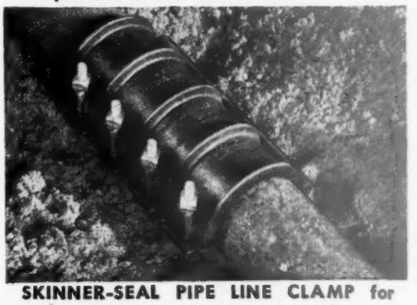
ANY PRESSURE — ANY TEMPERATURE

SKINNER-SEAL EMERGENCY PIPE CLAMP for pinhole or corrosion leaks.



SKINNER-SEAL PIPE LINE CLAMP for long splits and bad corrosion leaks.

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Pipeline

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for BETTER cleaning of

CRUDE LINES

PRODUCT LINES

NATURAL GAS LINES

*FOR DETAILS WRITE*

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## Products Line Meet Set for Philadelphia

One of the highlights of the fifth annual Products Pipe Line Conference sponsored by the Division of Transportation of the American Petroleum Institute to be held in Philadelphia in May, will be an all-day field trip to four pipe line and pumping installations in Eastern Pennsylvania.

The conference will be held May 10-12 in the Warwick Hotel. The field trip will take place on the second day, (May 11). Installations to be visited are those of Buckeye Pipe Line Company, at Macungie, Pennsylvania; Sun Pipe Line Company, at Knights Gap, Pennsylvania; and the Keystone Pipe Line Company, at Exton, Pennsylvania. Lunch for the touring conference members will be served that day.

On the agenda for the first day's sessions are a series of technical papers covering the following subjects: warehousing, oil soluble inhibitors, putting a new line in operation, storage tank equipment and maintenance, progress report on metering practices and calibration, and recent developments in microwave and supervisory control. Panel and round-table discussions will occupy the third day of the meeting.


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Cold Coating

FOR COATING AND WRAPPING UNDERGROUND OIL AND GAS PIPELINES-

Protecto Wrap Cold Coating provides hot applied enamel quality of material and workmanship on oil and gas pipelines. It is particularly recommended for reconditioning, and for field joints and repairs to coating.

Protecto Wrap Cold Coating is applied in two steps with the following described materials — either asphalt or cold tar base depending upon adjacent coatings.

1. Protecto Wrap Cold Coating Primer consists of a heavy bodied bituminous coating that is applied by conventional brushing. Care should be taken to thoroughly fill all pits on reconditioned pipe with primer.

2. Protecto Wrap Cold Coating consists of a woven glass textile cloth saturated with asphalt or coal tar pipeline enamel. This coating is applied by spiral wrapping over the primer while it is still wet.

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PROTECTO WRAP COMPANY
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## Kansas, Missouri Lines Planned by Cities Service

Cities Service Gas Company has applied for authority to construct a total of 33 miles of natural gas transmission lines in Kansas and Missouri to replace existing facilities.

The company plans to construct 24 miles of 26-in. pipe in Franklin and Johnson counties, Kansas, to replace two existing 16-in. lines, and to build 9 miles of 20-in. line in Cherokee and Jasper counties, Missouri, to replace an existing 16-in line. Total estimated cost of the project is $1,860,500, of which $227,500 represents the cost of reclaiming the 16-in. lines, the company reported.

The application states that the proposed 24 miles of 26-in. pipe would provide an additional capacity of 46,531,000 cu ft of gas per day on the company's system between its Ottawa, Kansas, compressor station and the Kansas City area. Total capacity of this portion of Cities Service Gas' system with present facilities is 427,729,000 cu ft.

## AGA Schedules Meet on Purchasing and Stores

The National Purchasing and Stores Conference sponsored by the American Gas Association will be held in Atlanta, Georgia, April 19-21. Purchasing and stores people will hear and discuss such subjects as types of buyers, material handling, methods of taking inventory, systems of inventory control, traffic, coordination of purchasing and stores, standardization, standard packaging, storeroom design information, cost reduction, personnel and answers to problems.

## New Lines Planned For Wyoming's Big Horn Basin

Montana-Dakota Utilities Company, Minneapolis, Minnesota, has applied for authority to construct and operate new pipe line facilities which would enable it to purchase additional natural gas in the Big Horn Basin in Wyoming, and sell natural gas to the Montana Power Company.

The company is proposing to build about 4 miles of pipe line in Big Horn County, Wyoming, and a metering station in Carbon County, Montana, to measure gas to be sold to Montana Power Company. In addition, the application also requests authorization for Montana-Dakota to lease and operate a 2640 hp compressor station in Big Horn County, to be constructed by Montana-Wyoming Gas Pipe Line Company.

Total estimated cost of the facilities, including the compressor station, is $789,676.

*For pipeliners—*

# quality is the payoff

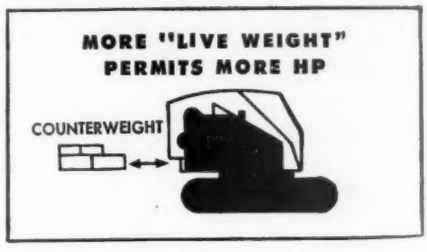
This ½-yd LS-51 trench hoe, owned by Somerville Construction Co., Ada, Mich., is working on a major oil company's pipeline.

## This LS-51 hoe, with *Speed-o-Matic* controls, does more work and costs less to maintain

THE Link-Belt Speeder ½-yd LS-51 is a quality-built machine from its track shoes on up. It delivers more *usable* hp, 55 net hp at full load speed . . . and it has the "live weight" or stamina to handle it (see box). And, there's Speed-o-Matic controls, the power hydraulic system that's proved itself the fastest, easiest to operate, most accurate and trouble-free control system ever developed for shovel-cranes.

When you buy an LS-51—as is the case with all Link-Belt Speeders—you get a machine built to handle anything in its work range. You won't have to keep "beefing" it up. You won't be getting "nickel-and-dimed" to death for maintenance. A standard LS-51 incorporates many work-speeding features found only as optional equipment on other rigs.

So get the facts now. Contact your Link-Belt Speeder distributor or write for catalog 2428.



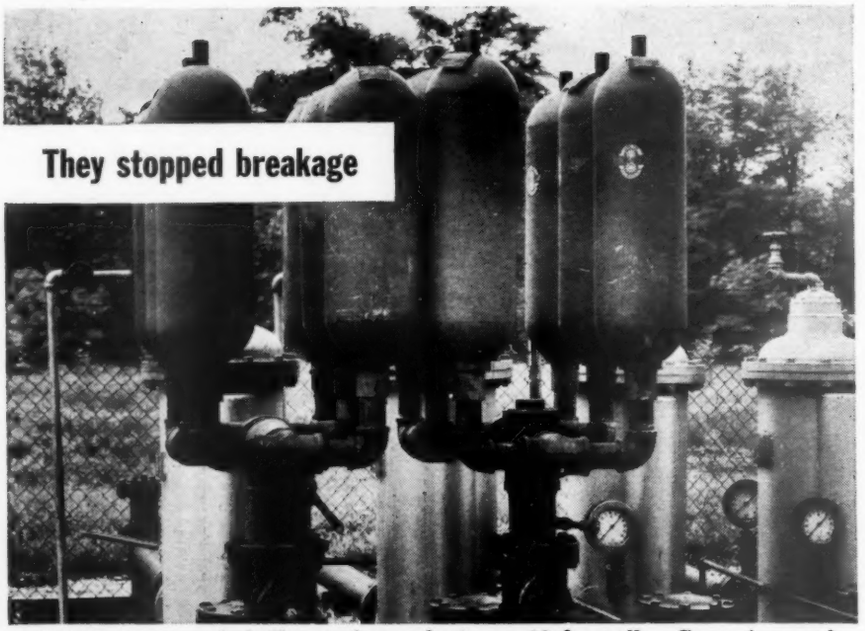

COMPARE ½-yd shovel-cranes with and without counterweights. This test spotlights the size, weight and heft built into the working parts and structure. You'll find the LS-51 has more "live weight."

LINK-BELT SPEEDER CORPORATION, Cedar Rapids, Iowa

13,476

BUILDERS OF A COMPLETE LINE OF CRAWLER, TRUCK AND WHEEL-MOUNTED SHOVEL-CRANES

**LINK-BELT SPEEDER**



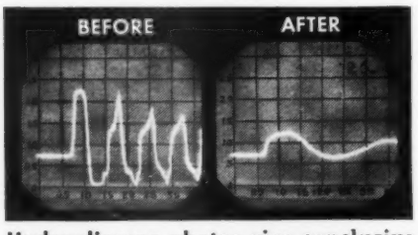

**Gulf Oil's Tonawanda** bulk petroleum plant uses 12 five-gallon Greer Accumulators in two manifolds to suppress valve closure pressure surges. Read details below.

PROVED AT GULF OIL'S TONAWANDA BULK PLANT

# Pressure Surges Tamed by Greer Accumulators

**Flowmeter breakage and line failure eliminated when Greer Accumulators reduce valve closure pressure surges from 235 psi down to 125 psi.**

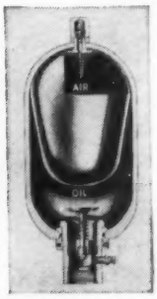
Whenever a valve was closed at Gulf's big distribution plant, sudden pressure surges were set up. The characteristic water hammer noise was heard and—more important—flowmeters were broken or their accuracy impaired.




**Hydrauliscope photos** give conclusive evidence: line surge was reduced over 100% when 3 valves were closed at once.

It seemed a complicated problem, yet the solution was simplicity itself. Six 5-gallon Greer Accumulators were manifolded to each truck-loaded rack inlet pipe. The accumulators absorbed most of the shock and—by lengthening the time-pressure relationship—took the impact out of what surge remained.

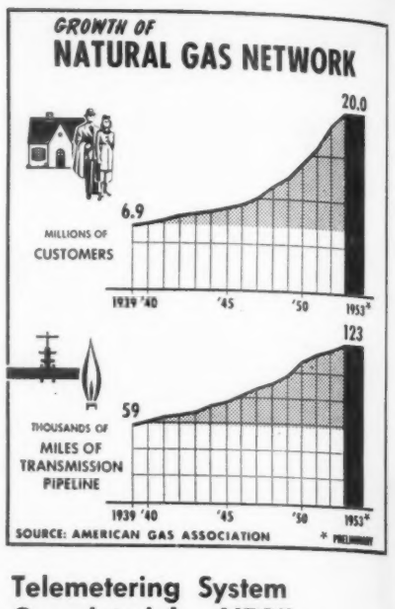
If you are concerned with a pressure surge or pump pulsation problem, our experienced application engineers can show you how Greer Accumulators solve it. Call or write.




**How accumulator works:** When system fluid is forced into accumulator under pressure, the gas in bag is compressed. Thus the rubber bag absorbs impact to an extraordinary degree. Write or call for Brochure 600 that gives data and diagrams on line shock suppression.
*U. S. Pats. under Olaer Lic.*

GREER ACCUMULATORS

**GREER HYDRAULICS INC. • 454 EIGHTEENTH STREET, BROOKLYN 15, N. Y.**
Field Offices in Chicago, Dayton and Detroit • Sales representatives in all principal cities


## Telemetering System Completed by NEGT

Northeastern Gas Transmission Company, Springfield, Massachusetts, has completed installation of a complete telemetering system by which a dispatcher at a central instrument panel is kept constantly informed of conditions in all parts of the gas distribution lines.

Northeastern, which serves a large portion of New England, receives its gas from the Tennessee Gas Transmission Company at West Lebanon, N. Y. Three measurements of gas flow and two of pressure are made at this point and transmitted by telemeter transmitters to Springfield, 85 miles away, over a single leased telephone circuit. In addition, remote adjustment of the control point on the automatically-controlled valves at West Lebanon can be effected from Springfield.

In the eastern area of the company's distribution system, pressure measurements at Concord, New Hampshire, Arlington, Haverhill and Malden, Massachusetts are "multiplexed" at Arlington, and sent to Springfield, again over a single leased circuit. A pressure measurement from Greenwich, Connecticut completes the system.

Measuresments from each point are recorded on separate receivers on a panel board in the dispatcher's office, thus allowing him to make decisions while fully informed on conditions.

## Shenandoah Line For Virginia Authorized

Shenandoah Gas Company, Lynchburg, Virginia, has been authorized to construct a natural gas transmission line to supply markets in northern Virginia and northeastern West Virginia.

The system will consist of about 40 miles of pipe line and will have an estimated initial construction cost of $1,466,500.

**HOUSTON, TEXAS.** Recently put into operation here for the Sinclair Refining Company is this 35,000 barrel-per-day crude distillation unit, designed and constructed by Fluor. The project also includes a vacuum unit to process bottoms from the West Texas crude still, and a desalting unit for crude being run on existing facilities. Construction began in May, 1952, and seventeen months later was completed on schedule and for less than the estimated cost – in spite of a three-month delay in steel procurement encountered during the 1952 steel strike. Products are propane, butane, pentane, gasoline, distillates, lubricating oil distillates and asphalt. Consult Fluor for engineering and construction services when limitations of time and costs are an important factor.

BE SURE WITH

**FLUOR**

THE FLUOR CORPORATION, LTD.
LOS ANGELES 22, CALIFORNIA

FOREIGN: FACTS-FLUOR · PARIS
FLUOR OF CANADA · TORONTO
FLUOR INTERNATIONAL · BEIRUT
FLUOR PERUANA, S.A. · LIMA
HEAD WRIGHTSON · LONDON

ENGINEERS
CONSTRUCTORS
MANUFACTURERS

NEW YORK
CHICAGO
PHILADELPHIA
BOSTON
PITTSBURGH
SAN FRANCISCO
HOUSTON
BIRMINGHAM
TULSA



To obtain more information on products advertised see page E-61

# *Unusual Tree,*

## But as Usual . . .

## ROCKWELL- Nordstrom VALVES

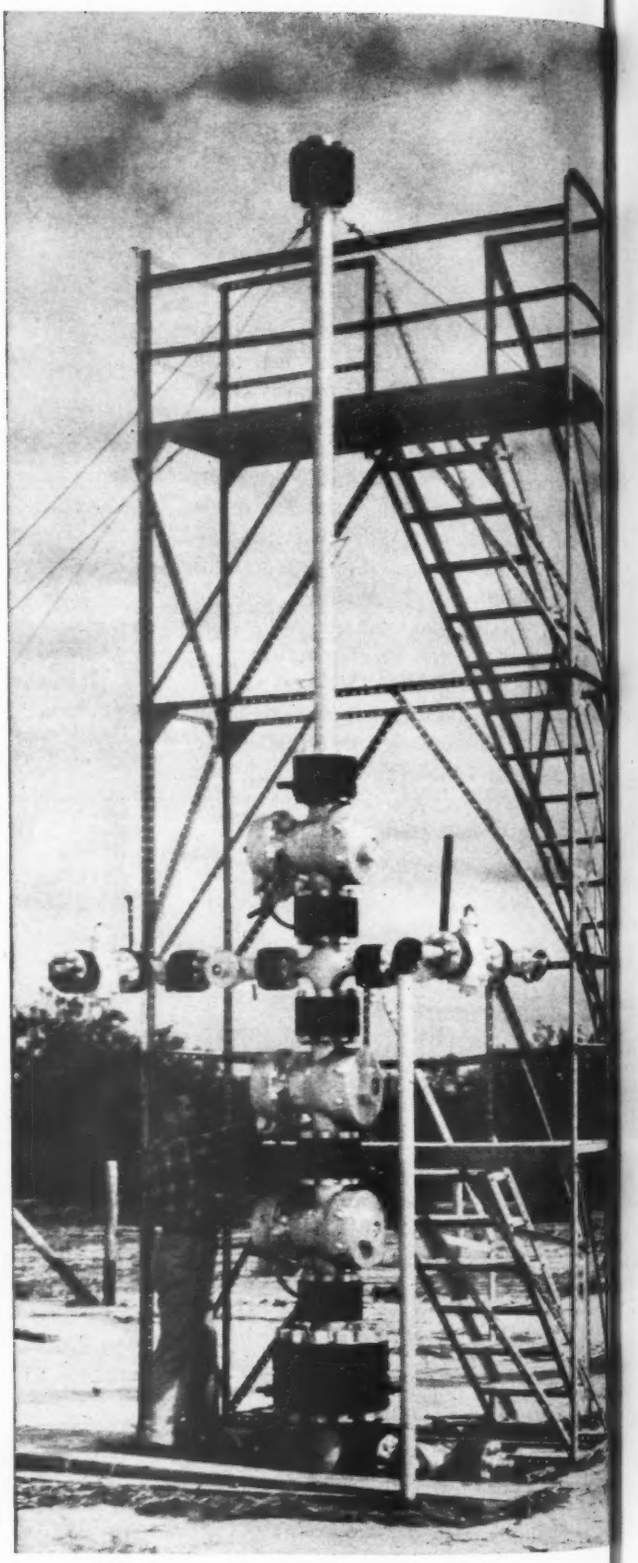
Certainly—you expect to find Rockwell-Nordstrom lubricant-sealed valves on all kinds of Christmas trees.

As it happens, this is a tree in the Freer Field, Duval County, Texas, with 15,000 lb. test, 10,000 lb. working pressure Rockwell-Nordstrom valves.

But it could be a low pressure tree, and it could be in California, or Arabia, or anywhere else where oil and gas flow from the ground.

No flowing well is safer than the valves that control it, and no valves are safer than Rockwell-Nordstrom. In Christmas tree service, where valves may stand in one position for long periods, yet must operate quickly and surely in an emergency, the Rockwell-Nordstrom principle of internal lubrication is especially important. The lubricant jacks the plug off the valve seat, and at the same time gives a slick surface for almost friction-free operation.

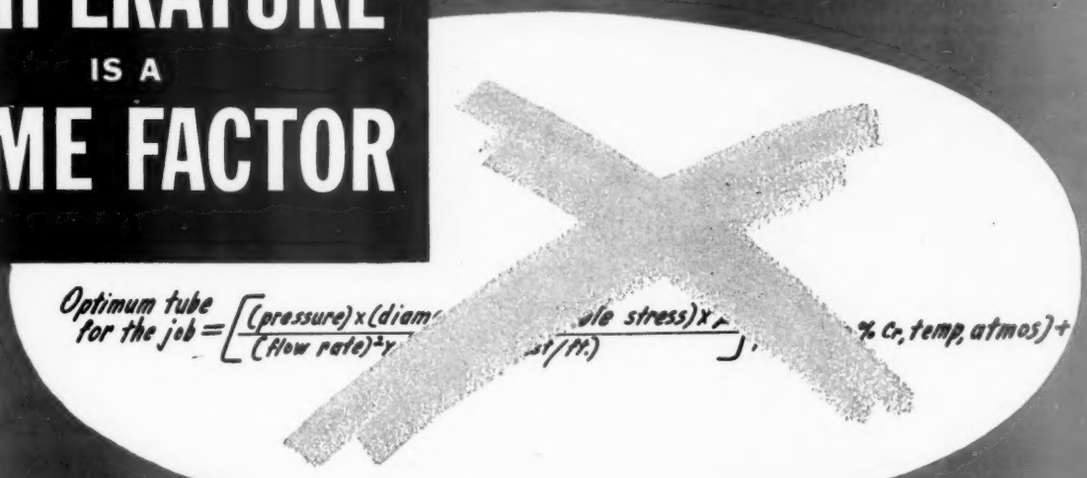
There is a proper Rockwell-Nordstrom valve for any Christmas tree service, readily available through oil country supply stores everywhere. Rockwell Manufacturing Company, Pittsburgh 8, Pa. *Canadian Licensee: Peacock Brothers Limited.*



## ROCKWELL- Nordstrom VALVES

*Lubricant-Sealed for Positive Shut-Off*

# WHEN TEMPERATURE IS A PRIME FACTOR




## Tube Selection Cannot Be Reduced to a Formula — Even a Complicated One

Many variables are involved in the selection of the optimum tubing for a specific high temperature application. If the tubing is also to operate under high stress, perhaps the most important variable to be considered is mechanical strength.

In general, the mechanical strength of a steel decreases as the temperature increases. Some steels, however, retain more of their strength at elevated temperatures than others. For instance, at 300F, the ultimate strength of both carbon steel and B&W Croloy 18-8 (Type 304) is about 70,000 psi. At 1200F, however, carbon steel is about 12,000 psi while Croloy 18-8 is about 44,000 psi.

To evaluate the characteristics of metals operating under stress at high temperatures and over long periods of time, B&W has performed stress rupture tests and creep tests on a great number of tubing steels.* The results of these tests help engineers to determine the proper tube to be used in specific applications.

Other factors beside mechanical strength, however, must be considered in choosing the optimum tubing for a specific high temperature application. Some of these factors are—oxidation resistance, tube size, tube cost, flow rates, and rates of conductivity and expansion.

It takes an expert to specify the right tubing for any particular application, and there is no substitute for the kind of experience with these problems you'll find at B&W.

To get the most benefit from B&W's long experience in matching tubes to jobs, call on Mr. Tubes, your nearby B&W Tube Representative. He can help you make the best choice.

*Data shown in*
*TDC 102 Creep Stress Data on B&W Croloys*

*TDC 153 Stress Rupture Data on B&W Croloys available free on request.*

**THE BABCOCK & WILCOX COMPANY**
***TUBULAR PRODUCTS DIVISION***
**Beaver Falls, Pa.—Seamless Tubing; Welded Stainless Steel Tubing**
**Alliance, Ohio—Welded Carbon Steel Tubing**

B&W SEAMLESS and WELDED TUBES

TA-4023 (P)

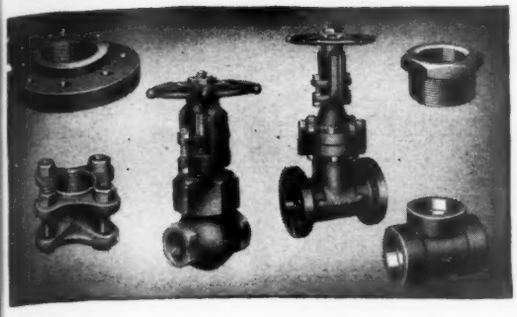


XUM

## PROPERTIES OF CONSTITUENTS OF NATURAL GASOLINE

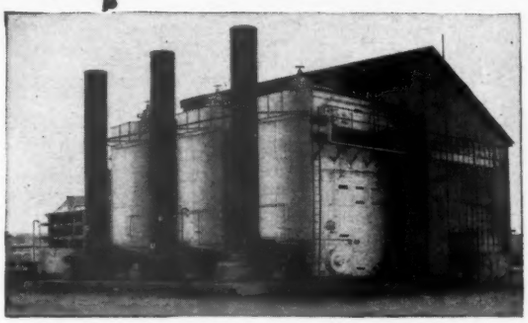
| Property | Constituent | | | | | | |
|---|---|---|---|---|---|---|---|
| | Ethane | Propane | Butane | Iso-butane | Pentane | Iso-pentane | Hexane |
| Empirical formula | $C_2H_6$ | $C_3H_8$ | $C_4H_{10}$ | $C_4H_{10}$ | $C_5H_{12}$ | $C_5H_{12}$ | $C_6H_{14}$ |
| Molecular weight | 30.05 | 44.06 | 58.08 | 58.08 | 72.10 | 72.10 | 86.11 |
| Specific gravity of gas (A=1) | 1.038 | 1.523 | 2.007 | 2.007 | 2.491 | 2.491 | 2 976 |
| Density. gas, lb. per cu ft. | 0.07949 | 0.11656 | 0.15365 | 0.15365 | 0.19074 | 0.19074 | 0.22780 |
| Cu. ft. gas per lb. | 12.579 | 8.579 | 6.508 | 6.508 | 5.243 | 5.243 | 4.390 |
| Cu. ft. gas per gal. liquid | 39.41 | 36.42 | 31.62 | 30.59 | 27.58 | 27.32 | 24.26 |
| Specific gravity of liquid | 0.3758 | 0.5092 | 0.5827 | 0.5637 | 0.631 | 0.625 | 0.663 |
| A. P. I. gravity of liquid | 245 | 146 | 111 | 120 | 93 | 95 | 82 |
| Lb. per gal. liquid | 3.133 | 4.245 | 4.858 | 4.700 | 5 261 | 5.211 | 5.527 |
| Gal. per lb. liquid | 0.319 | 0.236 | 0.206 | 0.213 | 0.190 | 0.192 | 0.181 |
| Boiling point, deg. fahr. | —127.5 | —44 | 30.9 | 10.0 | 97.0 | 82.4 | 156.0 |
| Melting point, deg. fahr. | —278 | —310 | —211 | —229 | —204 | —256 | —138 |
| Critical temp., deg. fahr. | 90 | 207 | 304 | 273 | 387 | 370 | 455 |
| Critical pressure, lb. per sq. in. | 723 | 654 | 542 | 536 | 486 | 484 | 435 |
| Specific heat of gas. $C_p$, B.t.u./lb. | 0.505 | 0.473 | 0.456 | 0.462 | 0.448 | 0.448 | 0.442 |
| Specific heat of gas, $C_p$, B.t.u./cu. ft. | 0.0406 | 0.0566 | 0.0728 | 0.0731 | 0.0854 | | 0.1006 |
| $C_p/C_v$ | 1.22 | 1.13 | 1.108 | 1.110 | | | |
| Heat of vaporization, B.t.u. per lb. | 210 | 182 | 164 | 158 | 154 | 158 | 143 |
| Heat of vaporization, B.t.u. per gal. | 658 | 773 | 797 | 743 | 810 | 823 | 790 |
| Heating value, B.t.u. per cu. ft. gas | 1,795 | 2,580 | 3,350 | 3,266 | 4,007 | 4,012 | 4.730 |
| Heating value, B.t.u. per lb. | 21,990 | 21,300 | 20,900 | 20,800 | 20,900 | 21.100 | 20,800 |
| Heating value, B.t.u. per gal. liquid | 68,600 | 90,400 | 101,500 | 97,800 | 109,900 | 109,900 | 115.000 |
| Lower inflammability limit, % | 3.2 | 2.3 | 1.9 | 1.9 | 1.4 | | |
| Upper inflammability limit, % | 12.5 | 9.5 | 8.5 | 8.4 | 8.0 | | |
| Mean coefficient of expansion, 0°—50° F. | .0028 | .00143 | .00096 | .00113 | .00081 | | .00070 |
| Mean coefficient of expansion, 50°—100° F. | | .00180 | .00113 | .00128 | .00089 | | .00078 |

# Designed for today's *Tough* service demands



**DROP FORGED VALVES AND FITTINGS FOR TOUGHNESS AND TROUBLE-FREE SERVICE**

Drop forged from carbon and alloy steels, Vogt valves, fittings and flanges will safely handle liquids and gases at high pressures and high temperatures in power plants, chemical plants, petroleum refineries, etc. The complete line includes flanged, screwed and socket weld end globe, gate and check valves—ells, tees, and crosses—couplings—bushings—plugs—unions—flanges and flange unions—and welding heads.

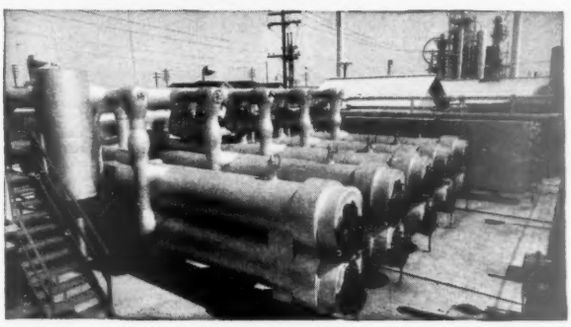


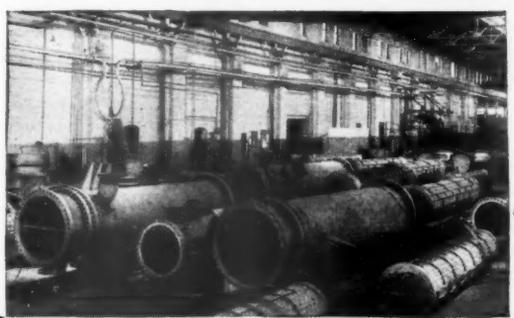
**MODERN STEAM GENERATORS**

Vogt steam generators are designed to give maximum rating in a minimum of space, with high efficiency and low maintenance expense. Bent tube types and straight tube, forged steel sectional header types to burn solid, liquid or gaseous fuels meet every power, process or heating requirement.

**PROCESS EQUIPMENT FOR EVERY SERVICE**

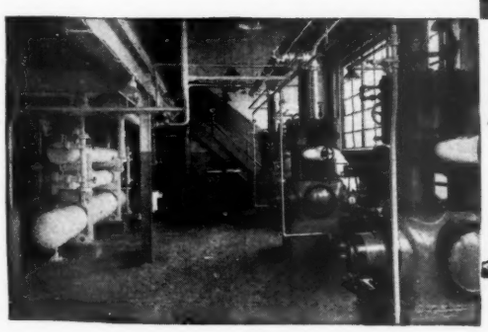
Vogt constructs process equipment in wide variety to all Codes. Stills and towers, oil chillers, crystallizers, heat exchangers, molding machines, etc., serve in the manufacture of oils, greases, 100 octane gasoline, synthetic rubber, chemicals and related products around the world.





**SPECIAL MATERIALS COMBAT CORROSION AND PRODUCT CONTAMINATION**

Our modern shops produce a wide variety of equipment from special metals and alloys to fight corrosion and product discoloration or contamination. Fabrication procedures insure that corrosion resistant properties of welds will match that of the materials used to construct the equipment.



# Vogt

## PRODUCTS

**FOR REFINERIES, CHEMICAL PLANTS POWER PLANTS AND PROCESS INDUSTRIES**

**HENRY VOGT MACHINE CO.**
**LOUISVILLE 10, KY.**

**BRANCH OFFICES: New York, Philadelphia, Chicago, Cleveland St. Louis, Dallas, Charleston, W. Va.**

**MORE REFRIGERATION TONNAGE AT LESS COST**

More than 70 years of engineering and manufacturing experience is incorporated in Vogt refrigerating and ice making equipment. Absorption Systems, Compression Systems, and Tube-Ice Machines in a wide range of capacities serve industrial and processing plants, and institutions, here and abroad.



XUM

# What chance do your valves have in a fire?

**Not much if your valves depend on "O" rings, rubber or synthetics for a seal. What's worse, a leaking valve can keep pouring fuel into the fire. But a W-K-M Valve, with its metal-to-metal seal on all sides, has the greatest chance of survival through the worst of fires. And it will hold tight to prevent further damage under conditions short of total destruction.**

**Wherever combustibles are handled, you can rest assured of the greatest possible safety factor when you specify W-K-M Valves all the way through.**

**W·K·M** *Valves*

**W-K-M COMPANY**

P. O. Box 2117, Houston 1, Texas • Los Angeles, California • Export Office: 30 Rockefeller Plaza, New York, N. Y.

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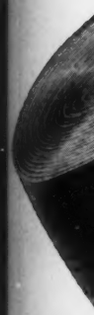
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PRODUC
THE PETRO
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For its North Dakota products line the Standard Oil Company (Indiana) selected

*New* Light-weight, reinforced

# TRANSHIELD

## ASBESTOS PIPE LINE FELT

**Stretching a distance** of 200 miles from Mandan, N. D. to Moorhead, Minn., the new products pipe line will provide a valuable link connecting the new Mandan refinery with the mid-western products pipe line system of the Standard Oil Company (Indiana).

## Permits high speed wrapping... assures effective protection for enamels

On the job shown above, coating and wrapping rates up to 17,000 feet per day were reported. This remarkable record is a tribute to Transhield's special tear-free reinforcement. This reinforcement is accomplished through the use of continuous glass yarns, parallel spaced on ¼" centers.

Designed for average soil conditions, Transhield is a light-weight felt composed of coal-tar saturated asbestos. This time-tested material assures an efficient barrier between pipe line enamels and earth loads . . . soil stresses.

As an outer sheath to retard cold flow, Transhield takes advantage of the full thickness of the enamel coating—working effectively toward preserving a continuous film of enamel on the pipe line.

**Long-Length Rolls**—Available in 800-ft. rolls (14" O.D., 2" I.D.) for traveling power-driven coating and wrapping machines. Other lengths can be furnished to suit your method of application. Widths are from 2" to 36".

Johns-Manville has developed three wrapping materials for pipe line protection:

**J-M 15-lb. Asbestos Pipe Line Felt** (perforated or unperforated)—for severe soil conditions.

**J-M Transhield Asbestos Pipe Line Felt**—for average soil conditions.

**J-M Trantex** polyvinyl pressure sensitive tape—for pipe line corrosion protection where ease of application is important such as when coating field joints of mill-wrapped pipe or making emergency pipe line repairs.

For further information write Oil Industry Department Johns-Manville, Box 60, New York 16, N. Y.

JOHNS-MANVILLE JM PRODUCTS

## Johns-Manville ASBESTOS PIPE LINE FELT



XUM

# BAROMETRIC PRESSURE CORRECTIONS—A. S. T. M. DISTILLATION TEST METHODS

| Fahrenheit temperatures | | | | | | Centigrade temperatures | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Temp. range °F. | Correction* °F. | Temp. range °F. | Correction* °F. | Temp. range °F. | Correction* °F. | Temp. range °C. | Correction* °C. | Temp. range °C. | Correction* °C. | Temp. range °C. | Correction* °C. |
| 36- 43 | 0.60 | 287-294 | 0.90 | 537-544 | 1.20 | 14- 23 | 0.35 | 265-273 | 0.65 | 515-523 | 0.95 |
| 44- 52 | .61 | 295-302 | .91 | 545-552 | 1.21 | 24- 31 | .36 | 274-281 | .66 | 524-531 | .96 |
| 53- 60 | .62 | 303-311 | .92 | 553-561 | 1.22 | 32- 39 | .37 | 282-289 | .67 | 532-539 | .97 |
| 61- 68 | .63 | 312-319 | .93 | 562-569 | 1.23 | 40- 48 | .38 | 290-298 | .68 | 540-548 | .98 |
| 69- 77 | .64 | 320-327 | .94 | 570-577 | 1.24 | 49- 56 | .39 | 299-306 | .69 | 549-556 | .99 |
| 78- 85 | 0.65 | 328-336 | 0.95 | 578-586 | 1.25 | 57- 64 | 0.40 | 307-314 | 0.70 | 537-564 | 1.00 |
| 86- 93 | .66 | 337-344 | .96 | 587-594 | 1.26 | 65- 73 | .41 | 315-323 | .71 | 565-573 | 1.01 |
| 94-102 | .67 | 345-352 | .97 | 595-602 | 1.27 | 74- 81 | .42 | 324-331 | .72 | 574-581 | 1.02 |
| 103-111 | .68 | 353-361 | .98 | 603-611 | 1.28 | 82- 89 | .43 | 332-339 | .73 | 582-589 | 1.03 |
| 112-119 | .69 | 362-369 | .99 | 612-619 | 1.29 | 90- 98 | .44 | 340-348 | .74 | 590-598 | 1.04 |
| 120-127 | 0.70 | 370-377 | 1.00 | 620-627 | 1.30 | 99-106 | 0.45 | 349-356 | 0.75 | 599-606 | 1.05 |
| 128-136 | .71 | 378-386 | 1.01 | 628-636 | 1.31 | 107-114 | .46 | 357-364 | .76 | 607-614 | 1.06 |
| 137-144 | .72 | 387-394 | 1.02 | 637-644 | 1.32 | 115-123 | .47 | 365-373 | .77 | 615-623 | 1.07 |
| 145-152 | .73 | 395-402 | 1.03 | 645-652 | 1.33 | 124-131 | .48 | 374-381 | .78 | 624-631 | 1.08 |
| 153-161 | .74 | 403-411 | 1.04 | 653-651 | 1.34 | 132-139 | .49 | 382-389 | .79 | 632-639 | 1.09 |
| 162-169 | 0.75 | 412-419 | 1.05 | 662-669 | 1.35 | 140-148 | 0.50 | 390-398 | 0.80 | 640-648 | 1.10 |
| 170-177 | .76 | 420-427 | 1.06 | 670-677 | 1.36 | 149-156 | .51 | 399-406 | .81 | 649-656 | 1.11 |
| 178-186 | .77 | 428-436 | 1.07 | 678-686 | 1.37 | 157-164 | .52 | 407-414 | .82 | 657-664 | 1.12 |
| 187-194 | .78 | 437-444 | 1.08 | 687-694 | 1.38 | 165-173 | .53 | 415-423 | .83 | 665-673 | 1.13 |
| 195-202 | .79 | 445-452 | 1.09 | 695-702 | 1.39 | 174-181 | .54 | 424-431 | .84 | 674-681 | 1.14 |
| 203-211 | 0.80 | 453-461 | 1.10 | 703-711 | 1.40 | 182-189 | 0.55 | 432-439 | 0.85 | 682-689 | 1.15 |
| 212-219 | .81 | 462-469 | 1.11 | 712-719 | 1.41 | 190-198 | .56 | 440-448 | .86 | 690-698 | 1.16 |
| 220-227 | .82 | 470-477 | 1.12 | 720-727 | 1.42 | 199-206 | .57 | 449-456 | .87 | 699-706 | 1.17 |
| 228-236 | .83 | 478-486 | 1.13 | 728-736 | 1.43 | 207-214 | .58 | 457-464 | .88 | 707-714 | 1.18 |
| 237-244 | .84 | 487-494 | 1.14 | 737-744 | 1.44 | 215-223 | .59 | 465-473 | .89 | 715-723 | 1.19 |
| 245-252 | 0.85 | 495-502 | 1.15 | 745-752 | 1.45 | 224-231 | 0.60 | 474-481 | 0.90 | 724-731 | 1.20 |
| 253-261 | .86 | 503-511 | 1.16 | 753-761 | 1.46 | 232-239 | .61 | 482-489 | .91 | 732-739 | 1.21 |
| 262-269 | .87 | 512-519 | 1.17 | 762-769 | 1.47 | 240-248 | .62 | 490-498 | .92 | 740-748 | 1.22 |
| 270-277 | .88 | 520-527 | 1.18 | 770-777 | 1.48 | 249-256 | .63 | 499-506 | .93 | 749-756 | 1.23 |
| 278-286 | .89 | 528-536 | 1.19 | 778-786 | 1.49 | 257-264 | .64 | 507-514 | .94 | 757-764 | 1.24 |

Above corrections are based on the Sydney Young equation:

For Fahrenheit readings

$$C_f = 0.00012(760-P)(460+t_f)$$

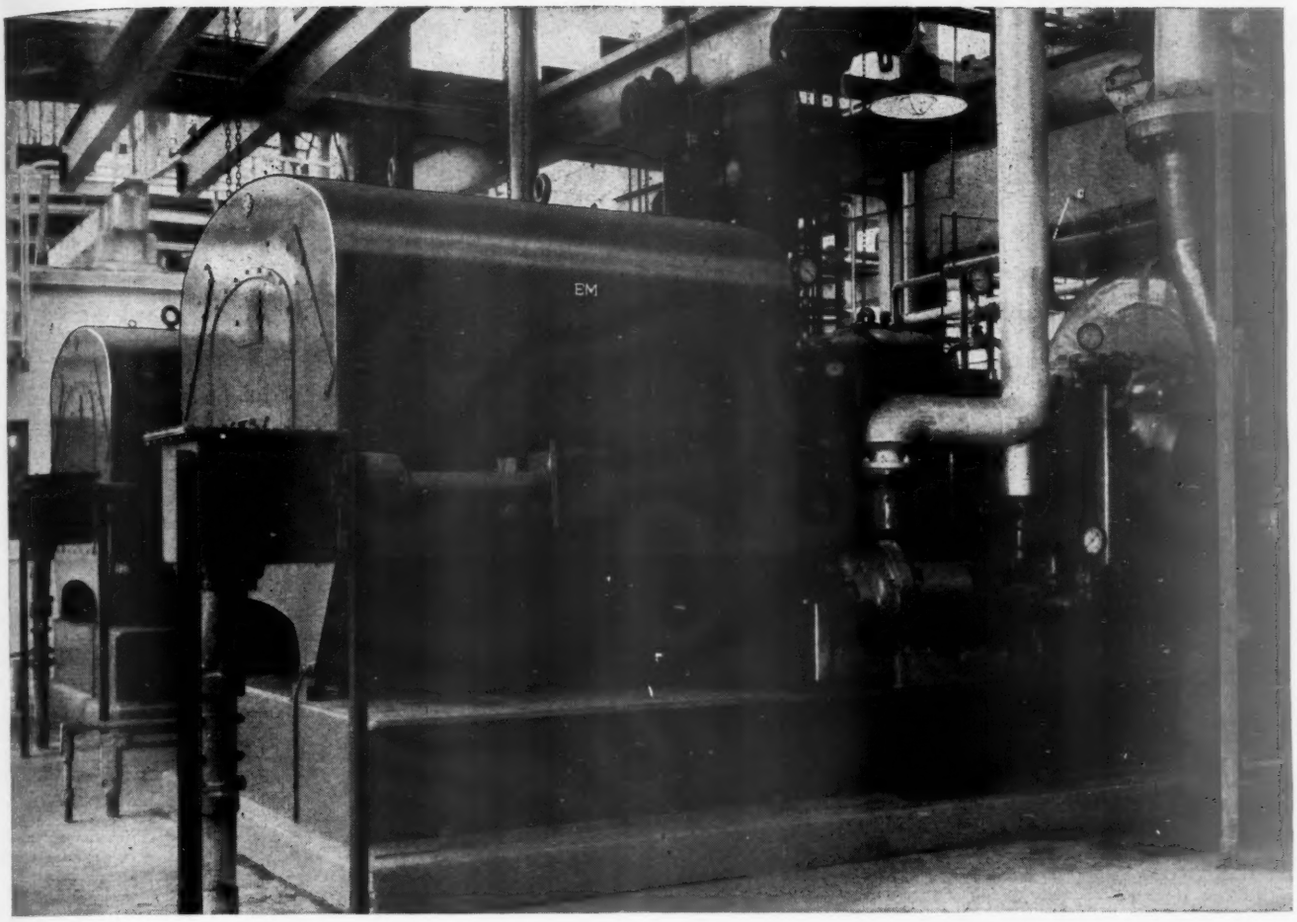
For Centigrade readings

$$C_c = 0.00012(760-P)(273+t_c)$$

in which $C_f$ and $C_c$ = the corrections to be added to the observed temperature $t_f$ and $t_c$, respectively, and P = the observed barometric pressure at time of test in millimeters of mercury.

*Correction per 10-mm. difference in barometric pressure. To be added when P is less than 760 mm., to be subtracted when P is more than 760 mm.

†This table may be filed under P 214.31 if preferred.



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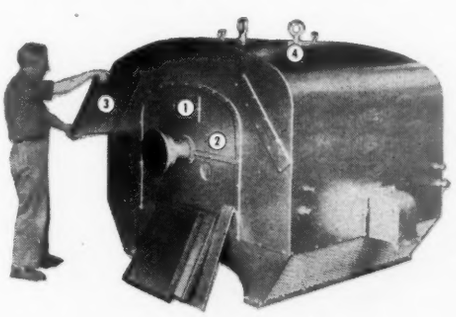


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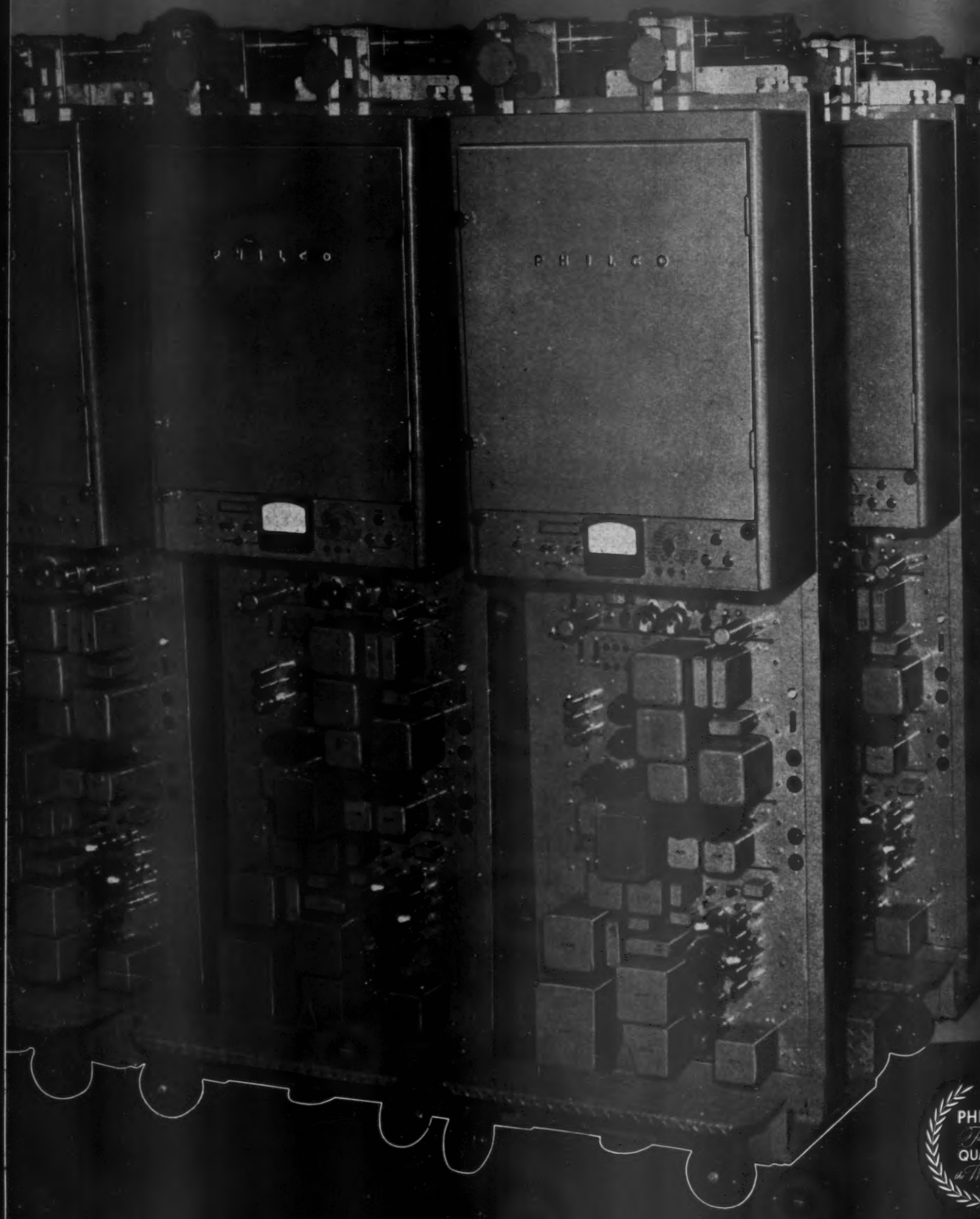


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*Need for engineers includes increasing demand for engineering background for management level — how do you train them?*

# Executive Development of Engineers†

W. C. ELDRIDGE*

MEN in the consulting profession are frequently tabbed as "experts," sometimes sincerely, frequently in sarcasm. I suppose at some stages we may qualify as experts on some subjects. However, we are so frequently impressed with our ignorance relative to the vast amount of current business knowledge that we have learned to get the facts early and to know their sources.

Out of respect for your individual and collective knowledge of executive development, we started our research early for this talk. We found so much current literature on the subject of executive development that talking on how to do it would be a duplication of many fine treatises.

Among all this heavy reading, we did run across a little comic relief. It seems that very few men can resist concocting their private definitions of executives.

One says — He is a man employed to talk to visitors so that the other employees will have a chance to work.

And another — An executive is a big gun that hasn't been fired yet.

It was apparent, however, that few attempts have been made to pull the various aspects of the problem together to indicate its magnitude. And so that's what I'm going do to. My remarks will be organized around these four subjects:

1. **The critical shortage of managerial talent,**
2. **Increasing demand for engineering backgrounds at the management level,**
3. **Action being taken to prepare engineers for executive responsibilities, and finally,**
4. **Some suggestions on tailoring programs to the specific needs of engineers.**

## Managerial Shortage

What evidence do we have of a critical shortage of managers?

First, there is the widespread holdover or deferred retirement of the top management group. We sensed the condition in 1949 and surveyed the managements of 65 companies to find out what had happened.

From the requirement standpoint, the survey established the fact that companies have been increasing their number of corporate officers. In 1929 there was an average of 7 per company, while by 1949 the figures had increased to 11.

With respect to tenure, taking the senior officers alone, (i.e., presidents, vice presidents, treasurers, controllers, and secretaries), they averaged 48 years of age in 1929 and 55 years in 1949 — an increase of 7 years. More significantly, the junior officers, who are normally regarded as replacements, averaged 52 in 1949 — just 3 years younger than the men they should succeed.

From these figures, it is apparent that replacements can't be postponed indefinitely. In fact, they will have to be at a more rapid rate in the next 5 to 10 years than in the past. Where will these replacements come from? Many of them will have to come from other organizations.

## Executive Turnover

It's the rather alarming increase in executive turnover that is the second piece of evidence of the general thinness that exists at management levels. Results of our survey earlier this year indicated that industry has been adding executives at a 46 per cent faster rate since the war and that it has been losing executives for reasons other than death and retirement at a pace one third faster than prewar.

Irrespective of the reasons for the individual moves, it is obvious that many of them would not have been precipitated if the executive doubted his ability to find a better berth elsewhere.

A third piece of evidence is the current interest in executive development.

One of the obvious indications of management's preoccupation with the development of managerial talent is the recent story in *Business Week*, titled, "Is It a Good Idea — or Just a Fad?" It points out that executive development was the top subject at last fall's conferences of the Society for the Advancement of Management. It noted that the American Management Association has launched a nationwide survey of what's offered in the way of executive development and is also sponsoring study of the subject by Lyndall Urwick, management specialist.

The volume of current publications on the subject also indicates widespread attention. Last year the American Management Association published a 575-page handbook of management development techniques and case studies called, "The Development of Executive Talent." API's manual on the development of men was published in April of last year. The National Industrial Conference Board's report on company programs of executive development came out in 1950.

The bibliography of a survey of executive development practice made by our own service research department last year lists 48 books and articles. Of these, 39 were written since 1950 — and the oldest only dates back to 1945. Bibliographies of other references paint the same picture of high current interest in developing managerial talent.

Now, let's look at some of the basic causes of the managerial shortage.

## Causes of Shortage

Since pre-World War II American businesses have been expanding rapidly both in numbers and size. The general statistics show a 12 per cent increase in number of companies between 1939 and 1950. Size-wise, the census shows that American businesses trended to larger units. In 1939, 10 per cent of the employed were in companies of 2500 employees and over. In 1947, 18 per cent were in companies in that size bracket. At the other end of the scale,

†Presented at the 28th Annual Fall Meeting of the California Natural Gasoline Association.
*Booz, Allen and Hamilton.

the percentage of employed in the 50 to 100 employee size group dropped from 11 per cent to 9 per cent.

In addition to larger numbers and greater size, there is the increased complexity of business operations.

It would take too much time systematically to tick off all things a business has to do today that it didn't do to any significant degree 20 years ago.

*There are things we do for the the government — such as collection of income taxes and old age benefits.*

*There are the things we do because of government — minimizing tax burdens, the contract accounting, depreciation and investment capital problems.*

*There are the new or expanded functions — industrial relations, public relations, research and development, big legal departments, etc.*

*There are all the complexities inherent in the mass production of highly engineered products — many which didn't exist 20 years ago.*

*Then, there are greater hazards of obsolescence.*

So much for the basic causes of increased demand. How about the supply?

In that same period, our management pool didn't expand to the same degree. The war effort killed a certain number of experienced managers. In addition to those who died in service, there was a significant number who died prematurely from overwork and nervous strain. There were additional numbers incapacitated, again, both in and out of service. The men who returned from service able bodied, had serious gaps in their experience backgrounds. Four and five-year shortages were fairly common among the 30-year-olds while the college grads were in many cases unable to start up the experience ladder in the normal manner because of established families. A smaller group couldn't face the transfer from supervisory positions in the military organization to the bottom rung of the business ladder. Many of these are lost for good.

Putting this subnormal supply of seasoned management against the great demand of this boom period — or even greater demands of a deflationary economy leaves a big gap unfilled.

### Increasing Demand for Engineering Backgrounds

"In the future, more top executives will come from the engineering ranks than from any other profession." I'm quoting Dr. Houston, President of Rensselaer Polytechnic Institute.*

*Collier's magazine, October 2, 1953.

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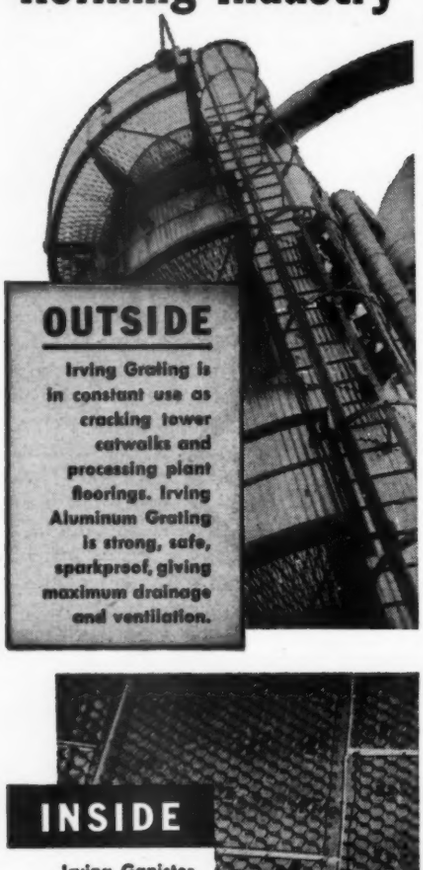

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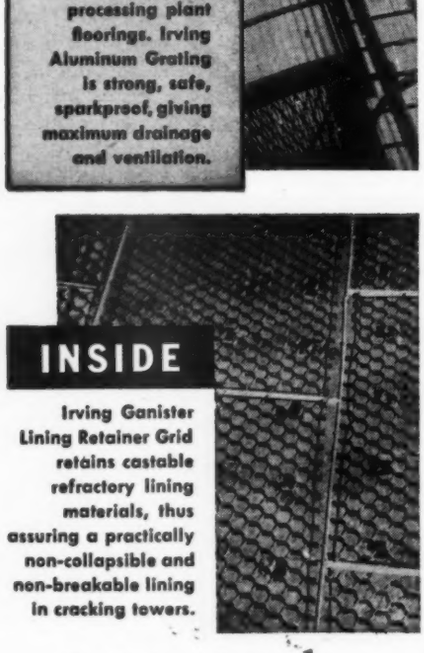

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Many of you probably have read this article titled, "The Engineers — They Have No Fears." For those of you who haven't read it, I'd like to mention the key points:

This year all the good engineering schools were besieged for their engineering graduates and next year it will be even worse. There were 5200 companies bidding for 1953 graduates with several major organizations seeking as many as 600 each. Top men could command starting salaries of from $7000 to $10,000 and even the poorest were assured of $4000.

According to the most modern estimates, American industry needs at least 32,000 new college-trained engineers. Last June, all the engineering colleges in the country graduated only 22,500 men and women, and 10,000 men out of the 22,500 face military service.

Not all of these requirements are for managerial timber. It seems reasonable that more and more engineers, however, will need to be trained for management.

What sort of special training problems this kind of a prima donna start will give us 10 years from now is anybody's guess. Where we are sure to feel the pinch is in our turnover rates among engineers.

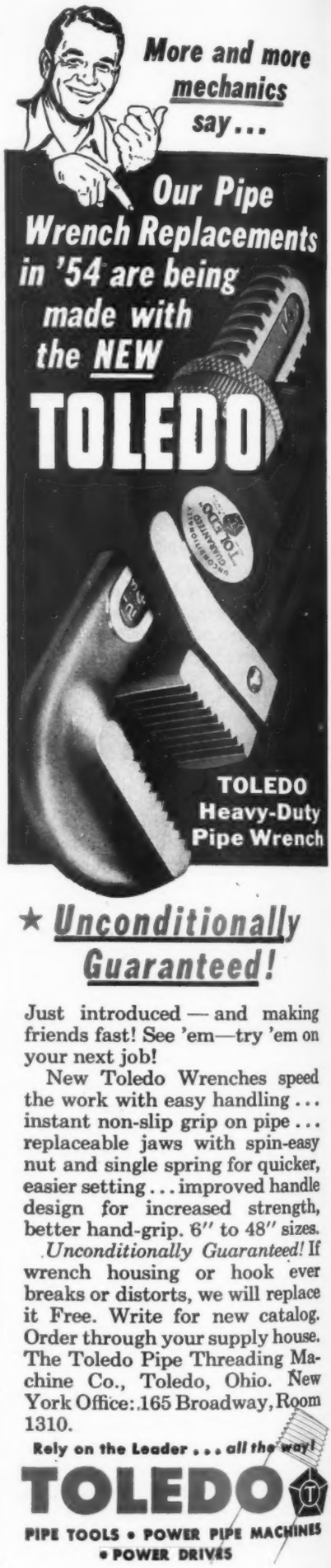
I'd agree with Dr. Houston, that more top executives will come from the engineering ranks, particularly if compensation is a factor. If an engineer is started out of college at $10,000 they couldn't afford to put him any place but the presidency.

Seriously speaking, the top executive generally comes from whichever function is most critical to the company's success — research and development, engineering, production, finance, or sales. Without increasing productive capacity, it's beginning to look like sales will be the critical function for a big percentage of American business before very long.

Dr. Houston went on to say that engineering is an excellent background for any other profession because of the exacting training it gives in learning to think, and in organizing one's work.

We should recognize that an executive is first of all one who thinks for, executes through, others. This definition distinguishes the executive mind from what we know as the creative mind, which may think out ideas for others, but is not responsible for, or concerned with, their execution and which may execute, but always alone and not through others.

A great deal of executive talent is being drawn from engineering ranks at the present time. J. G. Pleasants, Proctor & Gamble's vice president of manufacturing, gave these figures:

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**Nearly 30 per cent of technical engineers are engaged in administration and management.**

**A survey of 350 companies by the National Society of Professional Engineers reported that 92 per cent look to engineers for management, and practically all have managers who are engineers.**

### Preparation for Executives

If American business is going to put more engineers into management positions, let's take a look at what is being done to prepare them for broader responsibilities. First, in terms of undergraduate preparation, then postgraduate work, and finally what the corporations are doing to meet the problem.

In preparation for this talk we wrote most of the prominent engineering schools throughout the country to determine if, when, and how they have broadened their curricula to prepare engineering students for executive responsibilities. All of those replying indicated that the problem has received some recognition in recent years.

Going back 20 years, Carnegie Tech shook up its curriculum substantially in the middle thirties, in order to incorporate the humanistic element in engineering training.

Currently, each student in the College of Engineering and Science is required to take courses in Development of Western Civilization, Analysis of Change in Modern Society, Economic Analysis, and Psychology of Human Relations. He must also elect two senior courses in the social relations program.

Six years ago, Case Institute of Technology in Cleveland decided engineers were getting too much slide rule and too little general education. They added new faculty members in humanistics and social sciences.

Two years ago Lehigh University began "Professional Development Conferences." This is a senior course designed to bridge the gap between the campus and the business community.

USC's School of Engineering, about three years ago, added a course in human relations and leadership on an elective basis.

At UCLA, no such courses are required of engineering students, although many do elect courses in psychology, business administration, human relations, etc.

Cal Tech now requires that 25 per cent of the undergraduates' time be spent in the humanities.

These are typical examples of the action taken by colleges to broaden their engineering students.

The storage of management talent also has resulted in substantial efforts


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on the part of the country's colleges and universities at the post graduate level.

You are all familiar with Harvard's 13-week advanced management course for "middle" management. Some of you may have missed the news stories last June on its new 16-month program geared to handle 60 company-sponsored management men at one time. This expansion is typical of what is happening in many of the lesser-known educational institutions as well.

Another outstanding example which emphasizes several of the points already made in this discussion is the Sloan Foundation's new graduate School of Industrial Management at MIT. This school concentrates on the management of manufacturing industries. Alfred Sloan gives as one of his reasons for establishing the school at MIT his conviction that problems of production have become so complex and so technical that it takes managers with a strong engineering background to solve them best.

The curriculum is designed to counteract specialization — one of the characteristics of the engineer frequently singled out for criticism. Its major areas include organization — how men work together; distributing, in its broadest sense; and business' role in the social and political picture. These subjects are treated in a limited manner, if at all, in the average engineering major.

At UCLA they are preparing a program to train engineering executives. It is planned as a two-year course of evening classes leading to a master's degree.

Cal Tech has a well developed and highly respected industrial relations section available both to undergraduates and businessmen. According to its 1953 report one of the three major projects in supervisory and executive development — and for the third successive year.

Carnegie Tech established its graduate school of Industrial Administration in 1949. The statement of objectives contains some very quotable ideas on the executive development of engineers.

"The present way of life in America rests heavily on the contributions American business leaders and engineers have made . . . The future . . . will depend in large part on the men who rise in industry during the years ahead and on their capacities for efficient operations and broad-gaged leadership . . .

"The aim of the school is to select students of outstanding promise, and to help them build . . . for the future growth in industry, in civic responsibilities, and in personal life. Special emphasis is placed on preparation for work in industrial and business establishments where sound training in both engineering and management is required.

### Building Programs for Engineers' Needs

Now see if you don't think the following specific objectives of Carnegie's graduate work hit the nail right on the head as to what we need in our executive engineers to meet tomorrow's requirements.

1. *Thorough and integrated understanding of fundamental knowledge in management, economics, and engineering science.*
2. *Genuine competence in the orderly, analytical exploration and handling of problems, particularly in the industrial administration area.*
3. *Thorough understanding of the economic and general social system in which he lives and in which his business will operate.*
4. *A basis for dealing effectively with other people, both in person and through written communication.*
5. *The habit of learning from experience, including habitual receptiveness to new ideas and new ways of doing things.*
6. *Independence of thought and maturity of character.*

You may recall *Business Week's* feature story on Management Development. It included the case history of a chemical engineer who was an assistant general superintendent. When asked what good he got out of the six weeks' course at the University of Houston, he listed three advantages — first, forced reading; second, articulation; third, management background. He said he quickly realized that his knowledge of other functions such as marketing and labor relations was pretty fuzzy.

There has been some criticism of the rush to executive development programs as executed by educational institutions. It questions the effectiveness of the "short course," the quality of the faculties involved, and the hazards of discrimination within the management ranks of the individual companies participating.

To me, none of these is nearly so serious as the possibility of top management considering its executive development responsibilities discharged, when it arranges to have a certain number of its potential executives go back to school for a few weeks.

Just what are the corporations doing to develop their executives?

Seven years ago the National Industrial Conference Board decided to get answers to this question. It discovered there were not enough programs to form the basis for a report. When it tried again in 1949 it found plenty of companies with strong programs.

Significant among its findings was the fact that no two companies approached executive training the same way. The NICB report listed 20 different training techniques and to these we have added seven more that are used to some extent. As an indication of the prevalence of these 27 techniques, I've grouped them on a popularity basis:

There are five that appear in practically all company programs:

1. **Merit of performance reviews**
2. **Visits to other companies**
3. **Attendance at technical meetings and management conferences**
4. **Distribution of reading lists and management bulletins**
5. **Group meetings**

Here are six more that are often used:

6. **Job rotation**
7. **Advancement management courses at universities**
8. **Consultants**
9. **Committee assignments**
10. **Executive inventories**
11. **Job descriptions**

There is another group of nine that are sometimes used.

12. **Special trainee positions**
13. **Multiple management plans**
14. **Management cabinets**
15. **Understudy or assistant-to positions**
16. **Community leadership**
17. **Health and fitness programs**
18. **Individual counseling**
19. **Assignment to training or sales department**
20. **Sponsor plans**

In addition to these 20 there are seven more that are different to a degree:

1. **Problem solving**
2. **Role playing**
3. **Job observation**
4. **Training tours**
5. **Luncheon groups**
6. **Public speaking**
7. **Classes in human relations**

It's very apparent that it would take a lot of analyzing against your particular situation in order to determine which technique would be most bene-

† (Incidentally, you can read 25 different case histories of executive development programs and they all emphasize one essential ingredient; *top management participation — top management support.* From the descriptions of the time and effort required it is apparent that they are not thinking in terms of "sending the boys off to college.")

ficial. Because we are concerned today with the development of engineers, let's confine our thinking to the techniques that might be most appropriate for them.

To start out, we should know what attributes we are trying to build. The changes made in the curricula of the engineering schools are good clues to the shortcomings they detected in their graduates of the 20's and 30's.

They have in effect said they need broadening and to learn how to get along with people. Notwithstanding this opinion, the big corporations with executive development programs say they make no distinctions for their engineers. I personally do not conclude from this that they think the extrovert salesman and the introvert engineer need the same guidance in the handling of people, for example. What I suspect is that they are finding their executive development job big enough without tailoring the program to the specific needs of functional groups. Also there is the possibility of undiplomatic implications.

### Suggestions

For the executive or company that is willing to tailor a program to the specific needs of engineers here are a few of the undeveloped, I like to call them "flat sides," frequently found in engineers as a group.

First, and probably most important, with their training in logic and high regard for facts, engineers are inclined to expect individuals and situations to be governed by reason. Actually, the psychologists tell us man's motivation is emotional most of the time. Consequently, the engineer needs to know more about leading and handling people.

Second, engineers are a superior group intellectually and they are likely to show impatience over the degree of understanding and work pace of others. They can become very unpopular in the process.

Third, engineers are inclined to have narrow interests. They seem to concentrate on their chosen field to a degree that dwarfs the other functions of the business in their mind.

A minor point, in terms of ease of correction, is the overuse of technical terms — the jargon of a specific field of work. In conversation with other executives, the use of technical abbreviations and slang terms can be most disconcerting. I have in mind a very capable engineer in a staff capacity who confounds 90 per cent of his co-workers by launching into abstruse conversations. After he has discoursed two or three minutes beyond where he lost his audience, he finishes them off by asking "What do you think about that"?

So much for the generalizations of

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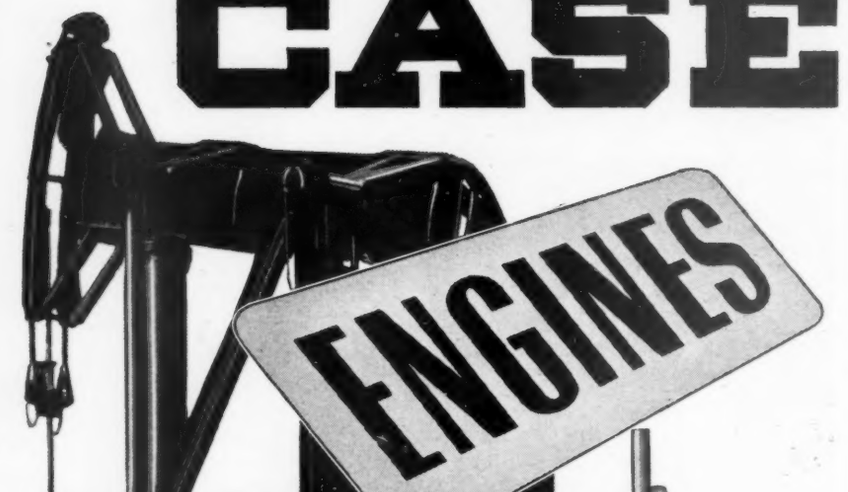


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# CASE


some of the flat sides that are frequently attributed to engineers.

Now let's get to some of the techniques that may prove particularly applicable to them.

### Performance Reviews and Individual Programs

We employ a great number of engineers in our own organization. All of them must be of management caliber because they are dealing with top management problems most of the time. We do conduct monthly staff development round table discussions. However, the absorption rate varies with the individual and his progress is not measurable from these sessions alone.

More effective from the individual development standpoint are the performance reviews conducted after every assignment. In these the man is rated on every element involved in good all-round performance and future progress. After two or three reviews the engineer knows his flat sides and has lost much of his sensitivity about them. He has discussed what he must do to correct them and subsequent reviews clearly tell him and his superior what sort of progress he is making. Every few months a fresh look is taken and additional suggestions made. This technique permits you to know the man much better, measure his progress, determine his readiness. Most important it gives you a sound reading on his character which in the last analysis determine how much of his development program he actually can accomplish.

Against the inadequacy in handling people, we can consider those techniques with people as a common denominator. These include:

*Group meetings — involving active participation in discussions*

*Committee assignments — in which the committee is made up of men from the other functions of the business.*

Multiple management plans, management cabinets, junior boards of directors, and similar devices serve to broaden as well as improve relationships with other people.

The case history of the assistant superintendent who spent six weeks at the University of Houston indicated he improved his communication and broadened his perspective. So formal schooling is a useful technique, although it is not company tailored or controlled.

In putting several techniques together they probably should be so balanced that they cover three aspects of the job:

1. **Recognition of what improvement is required, by both management and the individual engineer.**
2. **Programming over an adequate**

**period of time to produce results, and**

3. **Practice of what is learned in situations where assistance and constructive criticism can be provided.**

* * * * * *

I started out by telling you of the four subjects of my discussion. I'm going to close with an interpretation of what they add up to in my opinion.

Remember those figures about 5200 companies looking for 32,000 newly graduated engineers? Their managements are looking ahead. How far, or how accurately, no one knows, but it forecasts an unfilled need for particular talents.

With the heavy demand for engineers without business experience and the increasing requirement for engineering backgrounds in management, it certainly looks as if the seasoned engineer with management potentialities is a very precious item in your personnel inventory. How do you protect your "investment"? The full answer to this question is a subject for another day. It should be apparent, however, from the Collier's story that you should, as a minimum program, conduct a job evaluation analysis to be certain that your engineers are being compensated adequately and equitably in terms of other positions within your organization and similiar positions outside your organization.

As for the development of your precious assets, it might be safest to figure that if you don't, someone else will. My hope is that the combination of the facts as we covered them together here today does stimulate you to give more attention to the specific development needs of your own organizations. * *

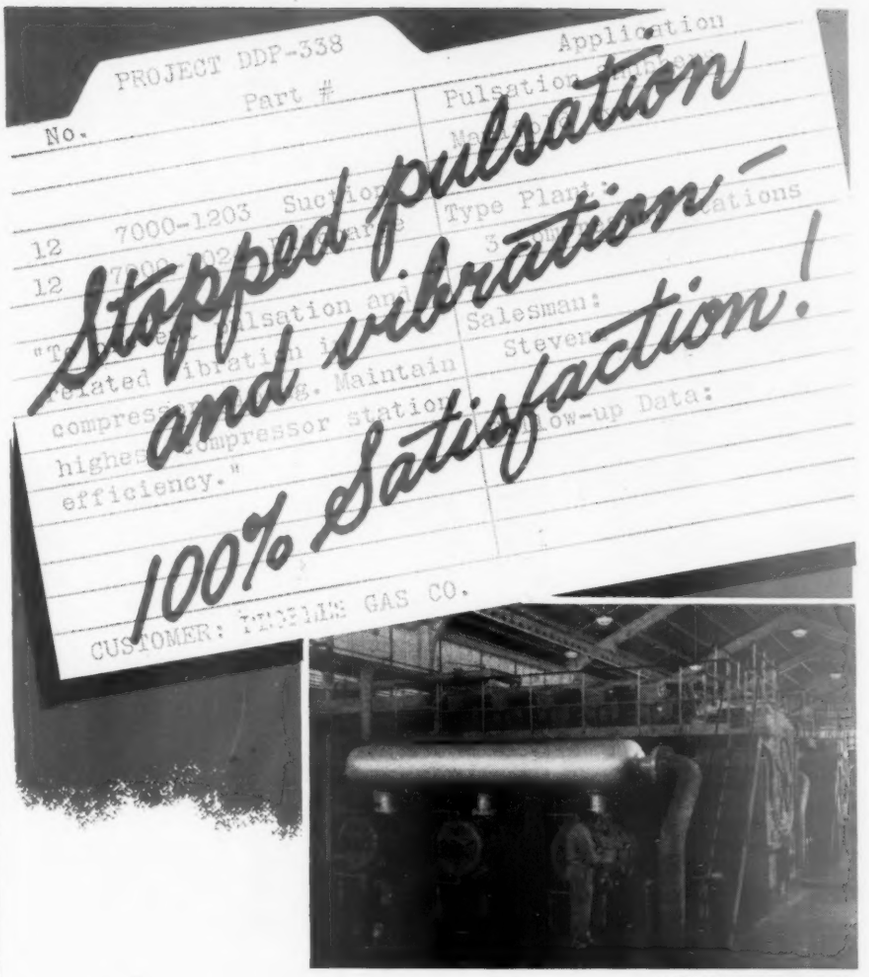
### Keep Employees Informed, McGill Urges Management

Tell your employees too much —rather than too little—about your business, and invite them to help you manage it.

That will help put you on the track towards success, a Standard Oil Company director advised business leaders recently.

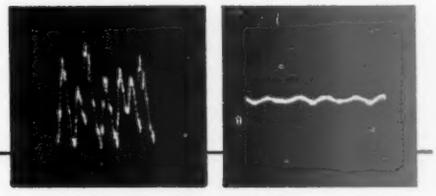
Speaking at a regional personnel clinic, Dr. W. J. McGill of Chicago, general manager of industrial and public relations for Standard, said every business should have a definite policy about employee relations. This policy should recognize the need for mutual understanding, he declared, adding:

"The main thing is to really want to let your people know what you are doing, and what you are thinking, and be interested in what they are thinking. Then tell them a little too much rather than too little and remember to listen."


Burgess-Manning engineers studied the compressor specifications and proposed station operations and designed and built pulsation snubbers of suitable size and construction to satisfy the pulsation dampening requirements. Surveys conducted during actual operation showed that these snubbers effectively eliminate the problems of pipe vibration and maintain compressor efficiency. This control was satisfactory even though actual operating conditions of the compressors were at considerable variance with the initial design conditions . . . proof of Burgess-Manning flexibility.

*Oscilloscope Traces recording pulsation on the compressor side of both suction and discharge snubber as compared to the piping side of pulsation snubber indicated effective elimination of the surge in the station piping, as indicated at the left. A smooth flow of gas was attained.*



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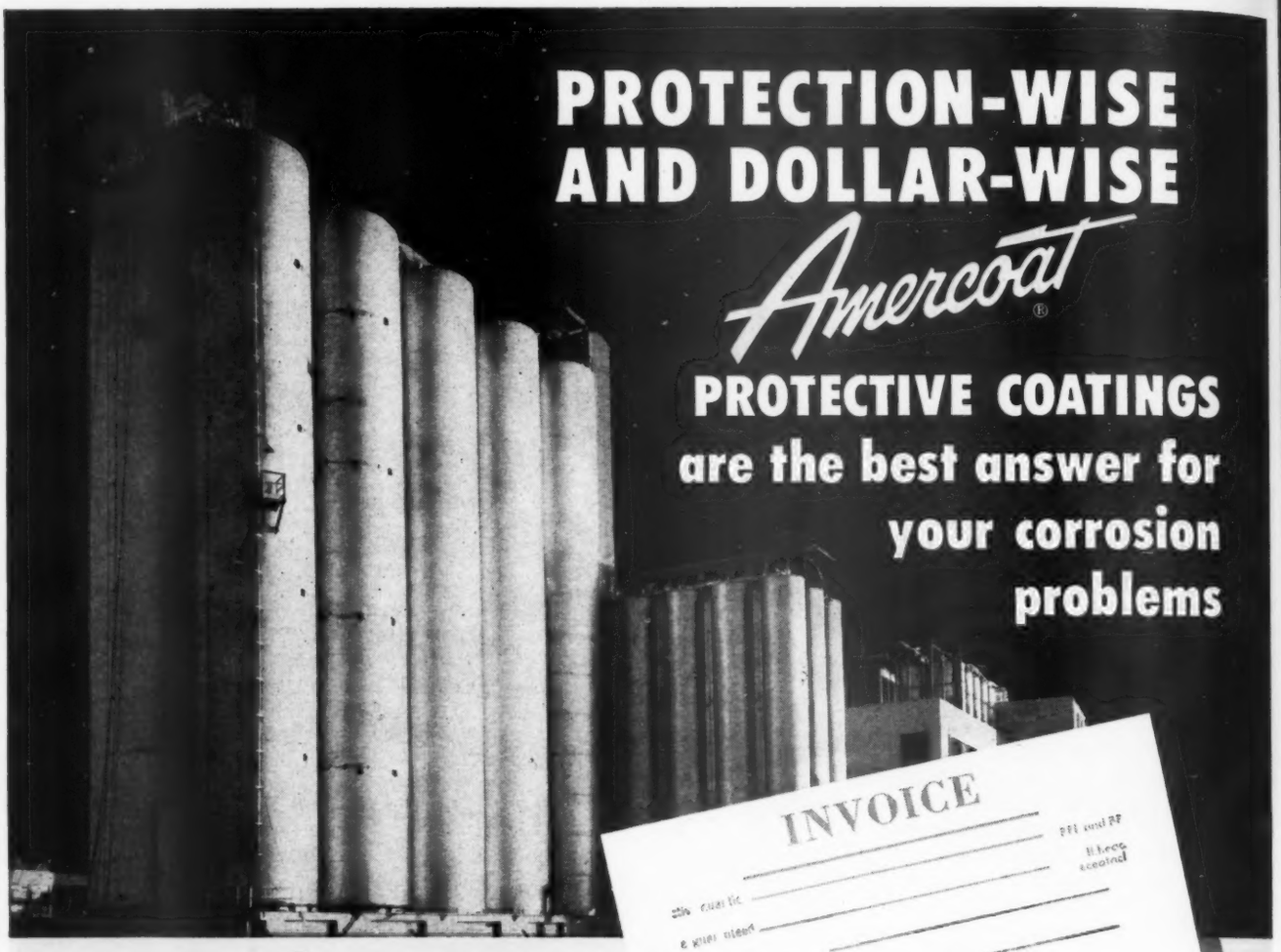


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Entrance to test chamber.

Harold Geisse turning relief valve.

*New Method Successful*

# LPG in Volume Can Be Stored Underground

•

**EARL V. CHAPIN**

A method of sealing to make possible wholesale storage of liquid petroleum gases in the underground caverns constructed in sand rock, has been perfected.

Success came after 21 months of experimentation by the United Petroleum Gas Company of Minneapolis, Minnesota. The series of tests was carried on in the Maiden Rock Silica Sand Mines near Maiden Rock, Wisconsin, by Harold L. Geisse, geologist. The new method of seal-coating entails application of a rubber-like hide on sandstone walls previously treated by a chemical solidifier and stabilizer.

With sandstone formations common in this area, the discovery is looked upon as a boon to this fuel-poor section. Development of underground storage of propane and related gases is held an aid to the region's heavy industry. Natural gas pipe lines from the oil fields of the Southwest are unable to economically supply fuel to meet peak demands. Twin Cities industrial plants are consequently forced to maintain stand-by overground steel tanks for peak demands.

As sandstone formations also occur commonly in the United States, this new method of seal-coating may provide an answer to the problem of low-cost storage of LPG throughout the industry. United Petroleum estimates that underground storage costs will be about one-fifth of the above-ground storage investment. Cost of excavation, bulkheading, and coating are included in this estimate. Maintenance would be much less in cost than that entailed by tank storage.

**EXCLUSIVE**

The search for a means of underground storage of LPG began in the spring of 1951. Proximity to river barge, rail and highway transportation facilities imposed limitation of site at the outset. Salt dome formations are not found in this area, and existing shale was not considered of a structure suitable as a containing medium.

The area, however, is characterized by deposits of sandstone. Principal formations of exposed Mississippi sandstone are the St. Peter and Jordan. The St. Peter is a white, friable, and very pure silica sand, containing considerable moisture. It is this sand that is being mined at St. Paul by the Ford Motor Company, for the purpose of glass-making. The Jordan formation—

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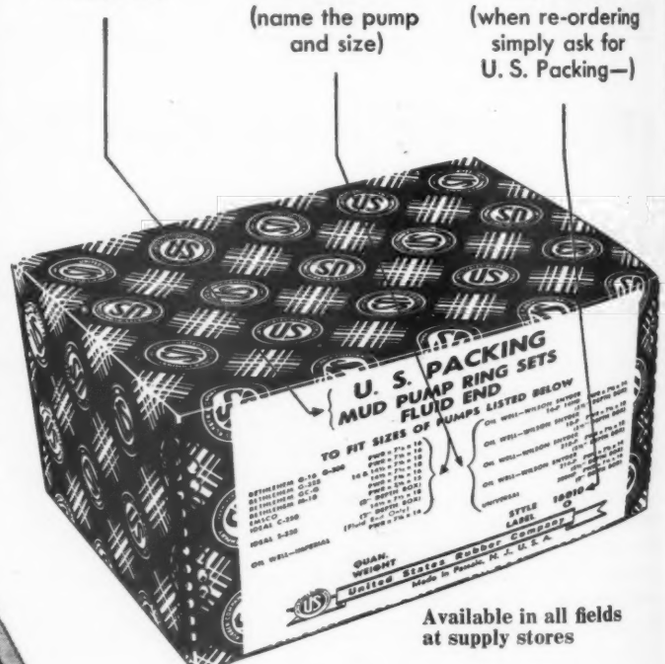


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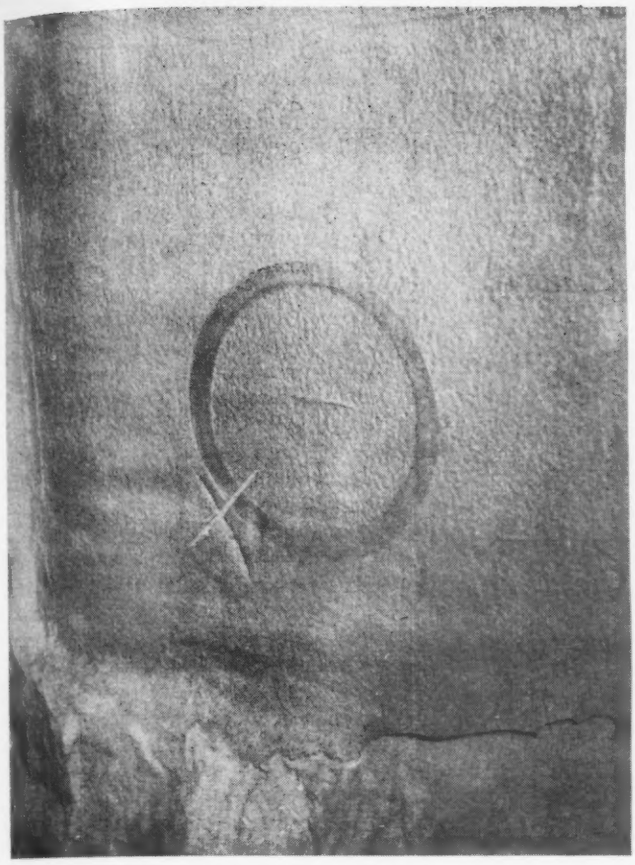

"X" cut in elastic coating covers depression

Coating containing protein attacked by mold.

older than the St. Peter — is usually medium-grained, white to yellowish-brown silica sand, quite friable in most horizons, but in some places so well cemented as to approach a quartzite.

Near Maiden Rock, Wisconsin, 60 miles southeast of St. Paul, the Jordan sandstone formation is exposed along the river at a point contiguous to barge, rail, and highway transportation. The drainage gradient into the geological valley of the Mississippi curves downward at some distance back from the river, rendering the formation virtually free of pore water in the bluffs adjacent to the stream. A very important consideration was the opportunity for extensive examination of the character of the deposit owing to extensive tunneling. Mining of sand had been carried on at this point for more than 30 years, and the tunnels obviated the use of a core drill with its uncertain results.

A laboratory was set up about 1000 ft from the mine entrance. Temperature was found to be 47 deg winter and summer, humidity usually 100 per cent.

First interest was the construction of an experiment chamber, 12 by 8 by 6-ft, cut into the sandstone, where stabilizers and coating might be put to test. A bulkhead was built to cut off a chamber about 10 ft back from the orifice. Taconite was used as the aggregate in building the bulkhead. The keyway was 36 in. deep on all sides. Results of injecting concrete into the forms by an intrusion pipe protected by a sheet iron hood to prevent dislodged sand from diluting the mix, was gratifying. The completed bulkhead was 2 ft thick. Reinforcing was ⅞-in. steel rod on 6-in. centers.

To prevent leakage at the periphery of the bulkhead, silicate of soda followed by calcium chloride to produce gelation were injected in a series of holes drilled into the sandstone 12 in. back from the face of the bulkhead, angling toward contact of concrete with sand.

The chamber itself was excavated by hand, using an explosive to knock down the sand. The interior of the experiment chamber was first sprayed with silicate of soda and calcium chloride in the effort to secure a seal. No attempt was made to dress the walls, which proved later to be a serious omission. A test with water disclosed that the chamber would not hold pressure. Dye was used in an attempt to trace the tanks. A four-inch concrete slab was poured over the floor, but the leakage persisted. The chamber ceiling was next impregnated with silicate of soda by drilling holes to a depth of more than a foot. The leakage continued, though the surface of the walls had hardened like solid rock.

A clue to one immediate difficulty was provided in noting that where the chamber wall was affected by the impact of dynamite blasts, the silicate of soda penetrated only superficially.

Experimentation was continued by forcing sealing chemicals into the walls by pressure. The surface assumed a dense, hard appearance, but subsequent water tests again proved this penetration method no more successful than other experiments with silicate of soda. The use of this compound was thereupon abandoned.

Silicate of soda had been Geisse's first choice for experimentation because of favorable results obtained by its use in soil solidification throughout the United States and in Europe. Geisse found the failure of the compound in this application to be due to its high lubricity. When injected into the pore spaces of the Jordan sandstone, with its adhesive moisture, the chemical moved so rapidly into the stone that the reactor — whether calcium chloride, fluorinate of zinc, or other acids — intercepted the silicate of soda tardily and at uneven depths, with weak intervals interspersing. Use of pressure in application of silicate of soda only hastened the retreat of the compound into the sand.

The search for a successful sandstone sealer was expedited by a re-examination of the nature of the moisture inherent in the stone. In a paper read before the Soil Stabilization Con-



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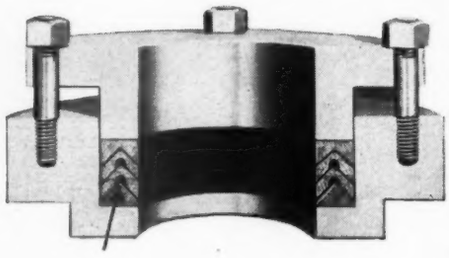

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▶ On hydraulic press—40″ ram, 6,000 p.s.i., ram honed and chrome plated, gland machined to give clearance of .006″ between gland and ram. Garlock 431 CHEVRON size 40″ x 41½″ x only 2″ deep gave 14 years service.

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gress at Cambridge, Massachusetts, in 1952, Dr. A. S. Michaels of the Massachusetts Institute of Technology classified types of water that may exist in soil as:

(1) Pore water. Normal liquid water.

(2) Solvation water. Found in layers around individual solid particles and held there by polar, electrostatic, and ionichydration forces. Denser and more viscous than ordinary water.

(3) Absorbed water. Present in thin layers around and in the particles. Virtually immovable by hydrodynamic forces.

(4) Lattice water. Caught in the crystal lattices. Removable only by heat.

This complexity of water within a soil mass provides an answer to why solids carried in solvents failed in numerous experiments in the Maiden Rock sand mine. Solvents in the main, are made from oil and oil derivatives. Applied to the Jordan sandstone, these solvents only entered the spaces vacated by the pore water. They were insulated from the individual grains of sand by incompatibility of oil products generally with the viscous absorbed water. On the other hand, a water emulsion is miscible with the absorbed water and leaves its solids firmly attached to the sand grains when the water content is reduced by curing processes. In working successfully at last with water emulsions, Geisse found that a moderate rise in temperature facilitated polymerization and accelerated curing of a coating. This cure was produced by use of heat lamps. The Minneapolis geologist points out that the inherent soil water acting as a lubricant for penetration of water emulsions, reveals why any hardening agent is ineffective on dry sand. It also explains why, in the first experimental chamber, wall areas directly subject to the violence of dynamite blasts, and its drying heat, inhibited penetration of silicate of soda.

The search for a compound to seal a stabilized surface, was laborious. This compound must have great adhesiveness, resist gas under high pressure, and be corrosion proof. Many compounds, supplied by chemical companies throughout the United States, were tried. Experimentation was facilitated by construction of a testing head improvised from the top of a propane cylinder. Designed to hold five gallons of gasoline at high pressure, thus simulating propane storage conditions, the device afforded a quick method of making a preliminary test. A section of wall would be sprayed with a new solution. The pressure head was then placed against it, braced from the opposite wall by four

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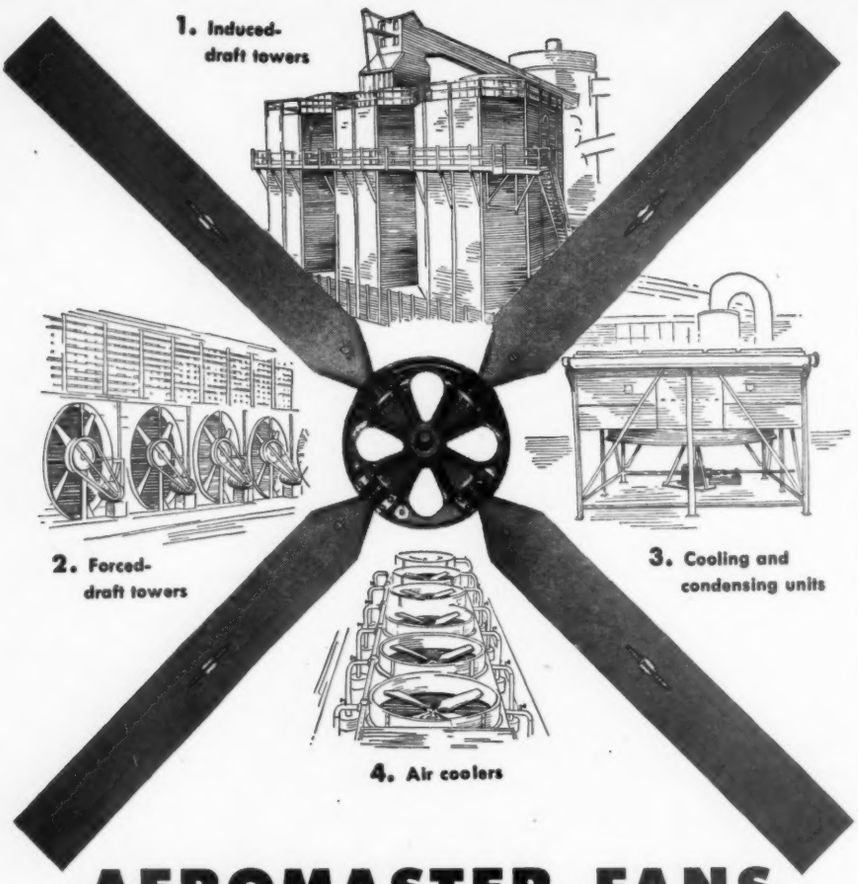


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pipes, with trench jacks. Gasoline was intruded into the bell through an injection valve. A relief valve at the top, and a gauge, completed the device.

In August, 1952, the West Chester Chemical Company, of West Chester, Pennsylvania, submitted to the United Petroleum Gas Company, in Minneapolis, a product called Syl-Seal, and "another sealing material" tentatively referred to as "Number 4." The latter, when tested at the mine, showed greater promise than any of the materials tried theretofore. Subsequent exchanges of information resulted in the eventual development of a series of materials based on the original compound. A small test chamber was constructed and coated with a West Chester primer which had displayed excellent penetrating qualities. This was followed by a compatible coating after the primer had been cured. The coated chamber was first subjected to 160 psi of air pressure. The air test indicated that the chamber was adequately sealed to warrant testing with propane. This was introduced gradually to a liquid content of 69 per cent of the chamber capacity. At the end of several months, the loss of gas was insignificant. There was a slight leakage at pipe joints and around the steel manway through the bulkhead, indicating the need of great care in providing adequately welded corrugation around any fittings placed in concrete.

When a compound used experimentally contained protein, it was found to be susceptible to bacteria. No material is desirable for a coating that is subject to shrinkage, as it drumheads over slight depressions. The water emulsion found most suitable is a neophrene base, silicone resin. A pressure as low as 15 lb at the gun was used successfully in application. Pump-type spraying equipment is considered by Geisse as less apt to produce pin-holing due to air entrapment.

Although Geisse's experiments were in the Jordan sandstone formation, he points out that any other sandstone with similar stability would be suitable for storage of liquid petroleum gases. In his opinion, sandstone is the most favorable medium in which to construct underground storage. Sandstone, he reports, has a degree of flexibility which does not prevail in any other rock, being free from fracture by ordinary earth movements, such as tidal action. Cheapness of excavating a chamber in sandstone, and the economy of constructing a horizontal entrance where the material may be conveyed out rather than lifted as in a shaft, are also cited. The Jordan sand in the Mississippi Valley is marketable for blasting sand, molding sand, and "recovery sand" in the oil fields. ★★

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**In summing up oil situation API President Porter finds that**

# Problems Are Always With Us

## But the petroleum industry is still doing all right

**FRANK M. PORTER***

MANY things have happened and much water has gone over the dam in the last four years that have had a bearing on the economy of this oil business. I might mention, among others, the Korean war, the refinery strike of 1952, and the impact of the fast-growing natural-gas industry. Then, of course, we have passed from a sellers' to a buyers' market in that the industry is confronted with a world-wide oversupply of crude oil and refining facilities. There should be, however, no cause for alarm. This industry is noted for its farsighted leadership and its ability to weather storms and emerge with a fair measure of stability.

One thing certain that has been for the better is that we are not continually confronted with representatives of the administration roaming around the country, attacking all business in general and the oil business in particular. The presidential elections of 1952 were, of course, the outstanding event of the period we are talking about. It is my sincere hope that the country will give the present incumbent a fair opportunity to carry out his program.

### One Problem Solved

It has been interesting to me to review the talk that I made here in 1950. Among the things discussed were the various problems then confronting the industry such as attacks on percentage depletion, legislation looking to the clarification of the Natural Gas Act, the importation of crude oil and products, tidelands, Congressional investigations, and attempts at the end-use control of fuels. Of these subjects only one has been laid to rest. That is the tidelands issue that has been resolved so that the states are again enjoying ownership of the submerged lands within their historical boundaries while the Federal Government has jurisdiction over the balance of the Continental Shelf.

I know that some people have a feeling, inasmuch as these problems are raised year after year and nothing happens to affect the industry adversely, that perhaps we become unnecessarily alarmed when we urge continued awareness. So, let me say to you that it is only through eternal vigilance and unceasing efforts on the part of many friends, associations, and individuals that we have been able to retain those things and those freedoms which have made this industry great.

Percentage depletion, which we all agree is the foundation stone upon which rests the entire economy of the production end of the business, has only been kept in its present form by the activities of those groups and individuals from this and other producing states who time and time again have rallied valiantly to the cause. This year bills have been introduced in the Senate calling for the reduction of the percentage depletion allowance from 27½ per cent to 15 per cent. Thus the industry is once more called upon to protect this all-important factor in its economic well-being.

Passing on to the Natural Gas Act and the necessity for clarification: The Supreme Court of the United States has under review a decision of a lower federal court which set aside a finding of the Federal Power Commission to the effect that after a full and complete investigation, the Phillips Petroleum Company was not a natural-gas company under the Act. Whichever way the Supreme Court may decide, the Natural Gas Act should be amended so that there will be no question in the future as to the exclusion of production and gathering.

I cannot stress too strongly the importance of this subject. As you may recall, efforts were made over the past 6 or 7 years to secure legislation freeing production and gathering from any possibility of being involved under the Act. The last attempt was in 1950 when the so-called Kerr Bill passed the House and Senate and then, due to the pressure exerted upon him, President Truman vetoed the bill.

Time does not permit a detailed statement of the many factors that entered into this fight which, after all, was to determine whether the producer of a raw commodity is entitled to a competitive and realistic price for his product or whether, by bureaucratic fiat, the consumer in the North and East should be given a price advantage to which he was not entitled. The fight was a bitter one.

The basic issues were: (1) Should the power of the Federal Government be extended to control the maximum price of a raw commodity while it is still in the hands of the producer or owner, it being accepted without question that gas in this instance is a raw commodity; (2) Should the conservation of this valuable natural resource be left to the states where it properly belongs, or should it be placed elsewhere by government edict; and (3) Should the Federal Government depart from its traditional role of regulating commerce between the states, thus bringing persons and corporations not engaged in interstate commerce under its jurisdiction.

Interesting in this regard is a statement by the National Oil Policy Committee of the API which says in part: "that natural gas is truly part and parcel of petroleum, is found by the same development methods as for oil, involving the same investment hazards and risks, and in the hands of the producer and gatherer is likewise entitled to equally free markets under our competitive enterprise system. The amount of energy contained in our available natural gas reserves is comparable in quantity with all other petroleum reserves.

"The decisions of the Federal Power Commission and the Courts that would subject production and gathering of natural gas and the price received by the producer, to control by the Commission are contrary to the intent of Congress and are preventing the move-

*Comments by the president of API at the spring meeting of the Mid-Continent district, API Division of Production, Biltmore Hotel Oklahoma City, Oklahoma, March 17-18-19, 1954.

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## Winslow Discovery Stops Sludge Show!

## Oily Critics Amazed by Performance!

**GETS TOP BILLING IN FILTER FROLICS**

by hedda lettuce

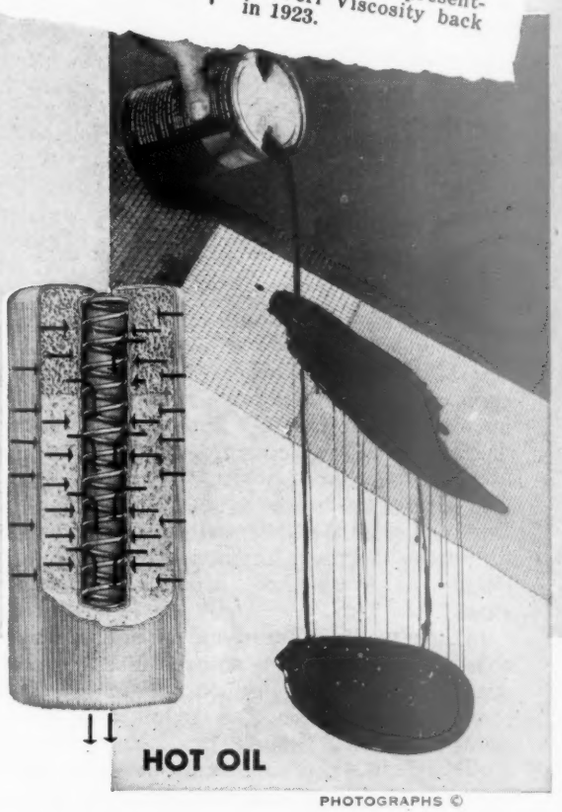
**EMERYVILLE:** Folks around here are talking about the sensational performance of "Cee Pee", the latest Winslow discovery who went before the cameras yesterday and came out smelling like a filter with a job well done.

Prior to yesterday's test there were those who doubted that "Cee Pee" had the stuff it took to be a star. But there's no doubt now.

"Cee Pee" handled her oil lines perfectly. Pressure didn't bother her. Not once did she find it necessary to open her bypass. It was a real Three-D performance—filtering, cleaning, and protecting.

It looks like a long term contract for "Cee Pee" with the industry. No one here has seen anything like her since Cecil B. DeMillwheel presented Veri Viscosity back in 1923.

**You can see for yourself why it is that a Winslow CP* element provides complete engine protection at all times, under either hot or cold oil conditions.**




PHOTOGRAPHS ©

Cold oil is poured over both portions of the screen. As can be seen the entire surface passes oil, with the majority going through the less dense section. There is no excess left.

In a Winslow CP* element there are also two sections, one more dense than the other. The less dense section is a very small portion of the entire assembly(1). Under COLD OIL conditions the Winslow CP* element reacts exactly as is shown in the screen test.

Under pressure the cold oil is all filtered. Dangerous particles are filtered out so that the engine is protected even under COLD OIL conditions. There is no unfiltered oil left to activate the by-pass. In a Winslow CP* element the by-pass acts *only* as a safety valve.

Under HOT OIL conditions the Winslow CP* element reacts exactly as is shown in the screen test. The less dense portion is still filtering some oil but the dense portion is taking more and more—automatically controlling pressure losses, as oil viscosity dictates.

Under HOT or COLD oil conditions *complete filtering of all the oil* is assured for within a single full-flow element the Winslow CP* performs as both a full-flow and a shunt filter.

(1)Strict field and lab tests have proved that even the less dense section of a CP* element will remove all particles of a harmful nature.

**WINSLOW FILTERS**

*FULLY PROTECTED BY PATENTS AND TRADEMARKS

**Winslow Engineering Company** **4069 Hollis Street · Oakland 8, California**

XUM

ment to consumers of vast quantities of natural gas under competitive conditions. A sound national policy was intended to be established by Congress in this regard in the Natural Gas Act of 1938, by exempting production and gathering of natural gas from such control. It is in the public interest, both of producers and consumers, that such control or threat of control by the Commission be removed by Congress."

Then we come to the question of imports and, strange to say, the issues are just about the same today as they were in March 1950. Domestic producers strongly contend that they have been injured by being forced to cut back their daily production and feel that imports are to a great measure responsible. On the other hand, the importing companies have not seen fit to reduce the volumes they bring in. It seems, however, that there has been a leveling-off in the daily rate. Surely there has been a genuine effort put forth by all parties concerned to bring about a fair solution of this complex problem without legislation.

Now as to Congressional investigations, I think we can still expect to have them periodically, but I do hope that we shan't again experience hearings comparable to those occasioned by an increase on June 15, 1953, in the price of crude oil and the resulting small advance in the price of gasoline. The written record of this hearing is not too bad from an industry standpoint, but unfortunately the attendant publicity followed the Washington pattern of attack.

In other words, it apparently did not constitute news for us to contend that these advances were justified and to prove that contention. On the other hand, unjustified attacks by demagogues are always spread over the front pages of the newspapers throughout the land. The report of these hearings has not been issued as yet. I am hopeful that it will portray the industry in a better light than was indicated during the hearings.

There never seems to be an end to attempts at legislation that would bring about the end-use control of fuels. Professional planners and would-be administrators, using the fallacious argument that we are fast becoming a have-not nation with respect to natural resources, constantly advocate a governmental bureau or agency that will tell the American people what type of fuel they shall use, in what quantities, and for what purpose.

Not only do we have this to contend with from some in government, but there appear to be outside influences also at work. Illustrative of this, about a year ago there came into being in Washington a non-profit corporation financed by the Ford Foundation known as Resources for the Future, Inc. Various companies and associations were invited to be sponsors of what was termed a Mid-Century Conference on Resources for the Future, with a meeting scheduled in Washington last December.

After due consideration the American Petroleum Institute agreed to be one of the sponsors with the thought that we might be helpful in keeping the project on an intelligent and constructive basis. It was also possible to secure the services of the Honorable Lewis W. Douglas to head the Conference as a public service. I believe the best way to summarize the actions and results of the Conference is to quote in substance a paragraph or two from a report by the API representative who participated in the deliberations:

"At the December meeting approximately 1700 so-called experts on the technical, economic, and social aspects of resources problems devoted three days to examining the natural resources position of the United States today and its future prospects. The Conference opened with a general meeting and then resolved itself into a number of panel discussions. The oil industry was mostly interested in the panel called 'Energy Resource Problems.' The original background material prepared for the discussions by the staff and by the Brookings Institution was very much on the pessimistic side.

"It was generally assumed that the United States was on the verge of depleting many of its natural resources and that these needed to be carefully conserved by stringent control over their end-use and by restrictions on the withdrawal of resources from the ground. I might note here that less than 10 per cent of the listed attendants at the Energy Resource Problems session represented the oil industry and that there was a very large attendance from educational institutions and government agencies. In view of this, there was a very good possibility that the forum would advocate strict government control over the country's energy and other resources.

"What really happened, however, was the complete reversal of this original theme. This was accomplished to a large extent by revising the questions to be considered, as well as by the vigorous opposition to such a theme presented during the meetings themselves. Industry participants expressed complete confidence that the energy needs of the country can be met and that the resources to do this are adequate and that the free-enterprise system can do the job with a minimum of government help.

"Another benefit of the Conference was that it presented opportunities for cross-education. Industry people, in particular, gave a great many discussions on such matters as the difference between crude reserves and ultimate availability of petroleum, the background and reasons for the depletion allowance, and the dynamic nature of the resource problem. The subject of depletion was handled by Roland Rodman of this city, in a superb manner.

"Due to the industry representatives at the Conference and to the outstanding leadership of Lewis Douglas, the program wound up as being on record in favor of the free-enterprise system and supports the view that resources are dynamic in nature and need no controls. The information is that the Ford Foundation is providing additional grants which will probably keep the things going for some time. If the work is continued in any manner, it is going to call for extreme vigilance to keep the conclusions along these same lines."

I have gone into some detail on this in order to impress upon you the fact that it takes the time and effort of many people to keep this industry of ours in a safe position.

At the outset I pointed out that we had passed from a sellers' to a buyers' market. This is, however, a fairly recent occurrence and the situation now seems to be somewhat stronger. You will all recall that the immediate post-war supply situation was one of relative scarcity. The industry had not recovered from the effects of the war and was producing about all the crude oil it could, and refining it, in order to satisfy the long pent-up civilian demand for our products. Being the dynamic industry that we are, this situation was improved to such an extent that the year 1948 actually was one of oversupply. Crude oil inventories increased considerably, and product stocks greatly, during that year. Of course, no industry can hope to overproduce its market consistently without the necessity of correction. Thus, 1949 was turned into a year of making up for past excesses and the doctor's prescription was not very easy to take.

Things were in an improved state during most of 1950, but by year-end the industry was again moving along at a pretty good clip. Even so, conditions at the close of the 1950-1951 winter were in better shape than they have been since. You have doubtless heard the expression, as I have, that the industry strikes of mid-1952 bailed us out of what appeared to be becoming a

bad situation. I have wondered many times whether or not "bailed us out" was a correct analysis. As a matter of fact, it is possible that the seeming "strength" which was said to have been injected into the situation because of the attendant shut-downs, resulted in a sort of trap into which the industry fell without full realization of what was occurring.

It is true that by reason of the strikes, both refined products, particularly gasoline, and crude-oil inventories were considerably reduced. This did necessitate increased activity all along the line and the industry was presented with two very definite operating problems which had to be solved at the same time. These were how to supply the on-coming 1952 season of high gasoline demand with the low levels of gasoline storage then in existence, while at the same time increasing the summer build-up of the middle distillate burning oils in preparation for the 1952-1953 winter.

As has been our record in the past, all units and divisions of the industry rose to the occasion and did the job. Of course we were at that time blessed with a considerable MER above market demand and a large amount of refining capacity that only needed the necessary crude raw material for its operation. The problems referred to were, therefore, readily solved but not without building up a tremendous momentum of crude-oil production and refinery activity that was difficult to slow down. It is, of course, a lot easier to open the valve on a producing well than it is to close it. It is also a lot more difficult, when a refinery has achieved maximum throughput and therefore the most efficient level, to slow that operation down than it is to continue it. Even so, crude-oil inventories kept climbing steadily; in fact, climbed almost continuously. And imports continued to climb also.

The immediate post-war threat of scarcity had alarmed the government and a number of substantial units in the industry. Long-term contracts covering supplies of foreign crude were entered into, tanker fleets were hurried from the drafting boards to actual construction, and here also a momentum was set up in that phase of operation that has been very difficult to arrest.

It should be stated here, I think, that some of the closer students of the industry, even as early as the fall of 1952, felt that levels of crude-oil production and refinery operation were getting out of hand. That feeling did not, however, appear to be generally accepted, but there was clearer indication in the late spring of 1953 that market demand was being oversupplied and that above-ground economic waste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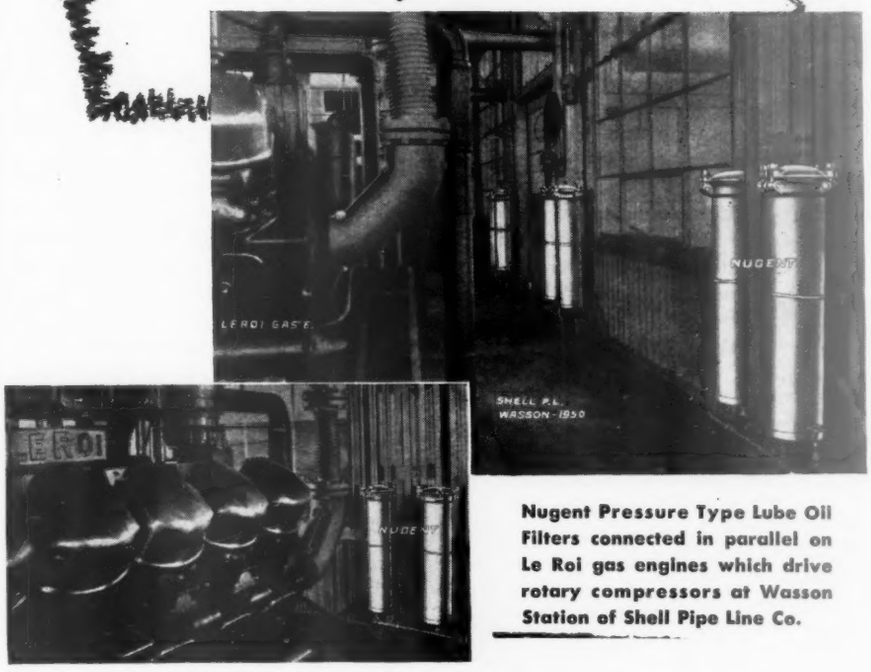


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might be present. The basic correctness of the statement that no industry can oversupply its market consistently without correction seemed again to have been realized. However, that apparent acceptance was not long retained; output was again increased but the situation soon indicated that such action was in error.

As a result, it became more evident than before that excessive supply had overtaken us, and in order to prevent above-ground waste a sharper curtailment of crude production was necessary. During all of this time we were drilling more wells and building more refining capacity. Our MER was going higher and higher and our technicians were no doubt anxious to find out whether the efficiencies that they had built into our new refineries would actually be accomplished in day-to-day operation.

We were under pressure from several angles. As we said earlier, it is very much more difficult to close a valve on a producing well than it is to open it; and it proved to be no less difficult to slow down a refinery. In addition, imports were continuing to move along at a fairly high rate. Full completion of ship-building contracts was achieved in many cases, and partial completion in others. As a result, tankers were also in oversupply and charter rates fell, making supplies from more distant points still more easily available. The momentum to import seemed to become greater and greater; but acting individually, the companies appear to have stabilized receipts at slightly above 1,100,000 bbl per day; generally 650,000 bbl of crude with the remainder in refined products, very largely residual fuel oil.

Many in the industry felt last fall that while the supply situation was way ahead of demand, normal winter weather would apply a corrective. That this was good thinking is reflected by the fact that since the arrival of more seasonable temperatures shortly after the first of the year, total U. S. inventories of middle distillates were reduced 54,000,000 bbl during the 8 weeks ended February 27, until, in the area east of California, distillate fuel oils and kerosine inventories were then lower than a year ago. Residual fuel oil stocks are also lower, but that product has not been in inventory or supply stress for some time.

Another improvement was found in the apparent realization by refiners, during part of the winter, that lower crude runs to stills were a necessity. These lowered runs made their contribution to the indicated lowered inventories of the products referred to and also slowed up the rate of additions to gasoline stocks. Yet over-all we remain, and particularly with respect to that product, in a buyers' instead of a sellers' market as heretofore.

Situations such as the one just described and the forces that generate therefrom do not happen overnight. They come about over a period of time. Sometimes they are discernible real early and sometimes they build up more slowly. At any rate, anyone interested in studying developing trends has available to him all of the means necessary for his complete understanding.

The petroleum industry is fortunate in having from both the Bureau of Mines and the Institute (API) and other sources, complete up-to-date statistical information from which these studies may be made. As I said, the changing picture was noted by some in its very early development. The same information that was available to them was available to all. Perhaps we are too busy or too closely occupied with our other daily pursuits, but it seems to me that those who do not give some time to observing these trends are neglecting an important part of their business.

When I spoke on another occasion in this city a little more than a year ago, I made the statement that the future of oil in the great Southwest was by no means dark. I still think it is a very bright spot in the petroleum picture. We have heard a lot about atomic energy recently, and some of the comments have indicated that this source of power, and even solar furnaces or some other new but now completely unheard-of or unthought-of medium might interfere with the oil-heating portions of our demand. It seems pretty well agreed, by the way, that atomic energy will never replace liquid fuel as the propelling force of our automobiles and trucks. But the English are continuing to state publicly that in the next decade or two all of their energy requirements will be met by the atom.

Not being a scientist, I do not find myself in a position to argue with this prediction, although I see a considerable number of problems involved not only in such complete practical application, but also in the rapid obsolescence of the capital investments now carried in the form of petroleum-consuming and other equipment, particularly when liquid fuel is available at a reasonable price. This, I do know, however — that our industry has attained leadership in energy fuel supply and, unless I miss my guess by a wide margin, it intends to retain that leadership.

The American Petroleum Institute is releasing for publication today a report of its Committee on Petroleum Reserves. The figures indicate a most successful year of oil and natural-gas finding for the country as a whole. More than 4 billion barrels of crude oil and natural-gas liquids combined were found in 1953. This constitutes a net increase in reserves of approximately 1 billion, 4 hundred million barrels after production of 2 billion, 600 million. The reserves of natural gas increased country-wide approximately 12 trillion cubic feet. This was after production of more than 9 trillion feet, or a total finding of gas during last year of about 21 trillion cubic feet. Not bad, I would say, for a country that some contend is running out of oil and gas.

I recognize, of course, that unexpected things might happen to mar what I conceive to be a bright picture. Certainly none of us are going to be entirely happy all of the time. Peaks and valleys we shall always have. They are the rewards and disappointments of the free enterprise system. This oil business of ours is doing all right. I do not even concede that some of the cream may have disappeared, but should that be true, the industry is still a darn healthy cow. * * *


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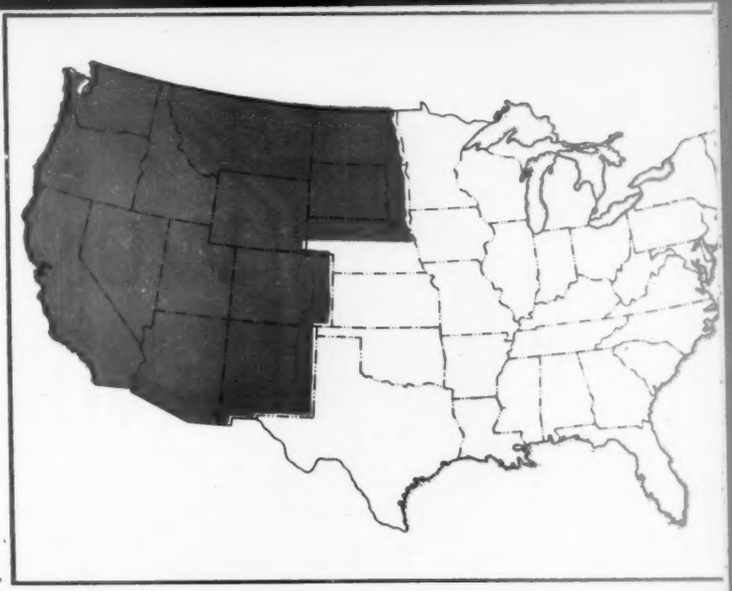
Federal expenditures for the year ending June 30, 1929, measured in income payments to individuals.



Federal expenditures for the year ending June 30, 1939, measured in income payments to individuals.

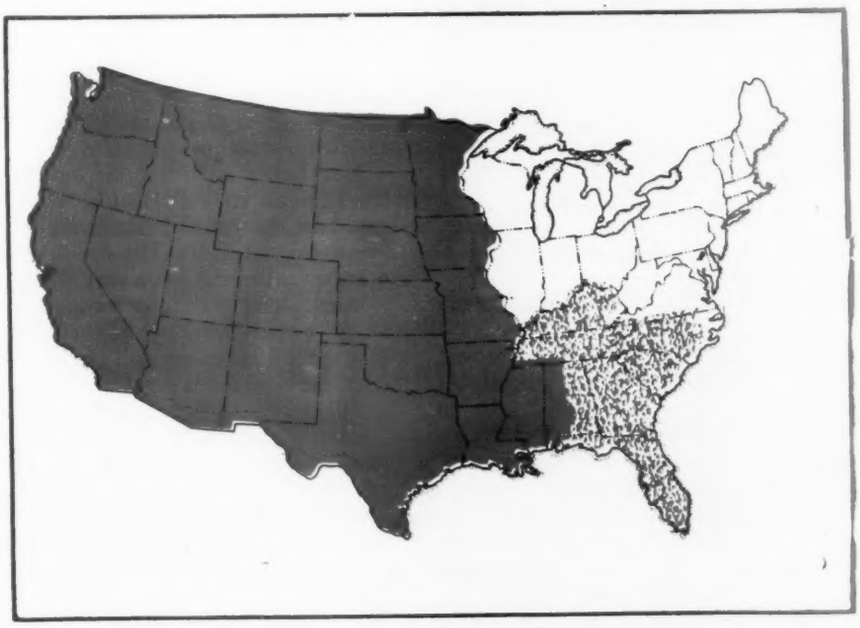
# THE EVER-LENGTHENING SHADOW†

*Working for the government is not limited to government workers*

FEDERAL expenditures for the fiscal year 1929 amounted to less than the total income payments to California's inhabitants, as is shown by the accompanying chart. In the fiscal year 1939, these expenditures were equal to the individual income of the Pacific and Mountain regions, together with that of North Dakota and South Dakota, and 42 per cent of Nebraska. For the fiscal year that ended June 30, 1953, estimated Federal expenditures required the equivalent of estimated income payments to all people west of the Mississippi River and, in addition, all income payments to the inhabitants of Mississippi and 55 per cent of those of Alabama.

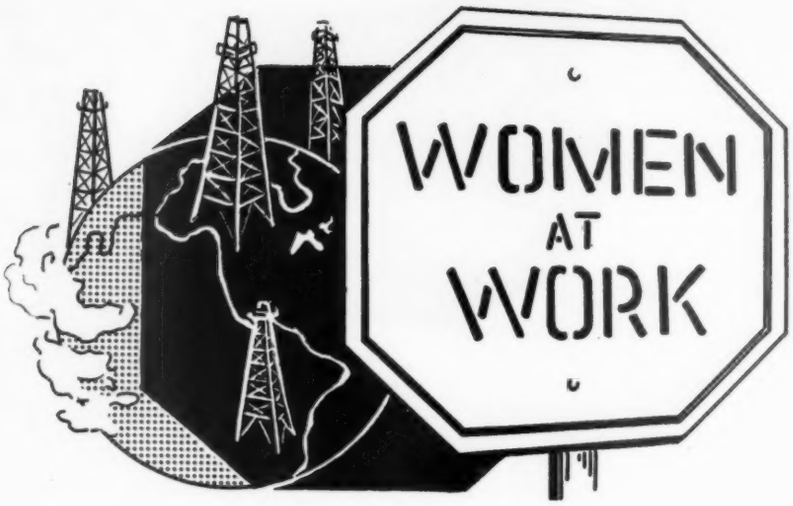
The foregoing data cover only Federal expenditures. If total state and local expenditures were added, the area would be extended to include the remaining portion of Alabama, all of the individual income to the people of Kentucky, Tennessee, Georgia, Florida, and South Carolina, and three-fourths of the individual income payments to inhabitants of North Carolina. This is shown in the solid color and dotted areas of the third chart. Those two areas account for 47 per cent of the nation's population; 83 per cent of the land area, 95 per cent of total crude petroleum production; 85 per cent of the lumber output; 70 per cent of the total value of mineral production; and 71 per cent of the total value of all farm crop production.

Total estimated government expenditures — Federal, state, and local — for the 1953 fiscal year was equivalent to the total wages and salaries of 75 per cent of the number employed in non-government pursuits in this country. Expressed in another way, these governmental expenditures approximated the total national income of Argentina, Belgium, Brazil, Denmark, France, Greece, Italy, the Netherlands, Norway, Portugal, Sweden, Switzerland, and the United Kingdom whose combined population aggregates more than 257 million persons. The Federal Government, alone, spent in 1953 more than was spent from 1789 through 1925, a period of 136 years. *



Federal expenditures for the year ending June 30, 1953, measured in income payments to individuals. Dotted area includes state and local expenditures.

†Revised from an article in *Lion Oil News*, Lion Oil Company magazine.




## Seaboard Officer

Cleo M. Jones holds one of the top jobs among oil women in Dallas. She is assistant treasurer, Mid-Continent Division, Seaboard Oil Company of Delaware, and she got there because she isn't afraid to take chances with her career.

"I have always wanted to work with figures," Cleo relates, "so in 1941 I applied for a job with Seaboard's statistical typing department. I was told there was very little chance for advancement."

**Holds a top job in Dallas.**

The oil business was strictly a man's world.

Women in many industries proved their value during World War II. At Seaboard Cleo Jones moved into an accounting position. Next, as the company expanded, she was promoted to a secretarial job. Then she was put in charge of the payroll department and the company's numerous employee benefit plans. Early in 1953 she was promoted to her present job.

Cleo was born in West Texas at Wichita Falls, grew up in East Texas, at Texarkana, and became a successful oil woman in Dallas. When she first came to Dallas in 1940 she had already made up her mind to get into oil.

"I had heard many favorable things about oil companies," she said.

During her steady climb at Seaboard, Cleo has taken several courses at Dallas College, one in personnel administration. She limits her outside activities to the things she likes best — square dancing and bridge playing. She is a member of Desk and Derrick.

Nobody lately has suggested to Cleo that the oil business is only a man's world.

## Raised in Oil

There's a popular TV and Radio Show called "What's My Line," and **Marthann Kessler** should get in on it. The experts might guess her to be a model or a dance instructor or a college coed. They'd be wrong. Marthann now is studying correlations by insoluble residue analyses of well cuttings and cores for Stanolind Research Center in Tulsa, Oklahoma.

"Though I can't remember any do-or-die dedication to the oil industry," Marthan says, "I got my training the easy way — by growing up in it."

Her father followed the oil trend from Illinois and has been actively engaged in the industry since the early boom days in Tulsa. His daughter remembers when she was a very little girl, trotting along with him to the wells. She was much older before she learned that the oil language and the English language were not necessarily the same.

When it came time to enter college, Marthann enrolled at Texas University — in geology naturally. She received her BA in 1943 and joined Stanolind shortly thereafter. On-the-job training with a microscope and several years experience in selecting samples from well cuttings for density determinations laid the groundwork for her present job.

Extra curricular activities include participation in Alpha Phi Sorority Alumnae, Desk and Derrick, Tulsa Geological Society, the American Association of Petroleum Geologists and the Women Geologists of Tulsa. Creative Marthann also likes handwork and sewing — when she can find time for it.

One of Marthann's particular delights is interior decorating. Until recently when Stanolind gave its employees a spacious new lab, she was constantly persuading her fellow employees to "shift a few desks, filing cabinets, and storage shelves so that we can work together more efficiently." Now, with every inch of space planned by experts for high efficiency and most of the furniture built in, there's no occasion for furniture moving.

**Well cuttings and core analyzer.**

"The men," Marthann confides, "are most relieved. I must admit I feel frustrated!"

## Owns Scouting Service

Tragedy pushed **Kay Olson** into the oil business. Her husband had established and prospered at Olson Scouting Service in Los Angeles, California, and Kay often discussed the business with him and accompanied him on trips. Her main interest, however, was in her home and the four little Olsons.

Then, quite suddenly, in October 1947, Edwin Olson died, leaving Kay with Joan 10, Barbara 8, Edwin 5, and Michael, 11 months—and a business. Kay was faced with the problem of learning the business and continuing it or giving it up and going back to a business career, in which she had some training and experience. Kay chose to hold on.

She hired an engineer to help her learn the ropes. She took a course in petroleum map drafting at the University of California. She took the advice →

of those who used the Olson Service . . . she disregarded the advice of those who said it couldn't be done—and she succeeded.

The Olson Scouting Service publishes a Weekly Development Report which includes full information on every drilling well in California. It also

She chose to succeed.

publishes a Drilling Contractors Report. Since 1928 the Service has kept complete well records.

Kay's work week is divided into two parts: During the first of the week she's in the field calling on customers and keeping in touch with active developments. The latter part of the week she's home at 108 West Sixth, Los Angeles, checking and preparing data and meeting a Saturday morning deadline.

The Olson Scouting Service has grown steadily under Kay's guidance. Five employees assist her in gathering information, maintaining records, answering requests.

"Mine," says Kay, "is an unusual profession for a woman, but a fascinating one."

With her heavy work schedule and her home responsibilities, Mrs. Olson does not often find time for clubs, hobbies and sports. She is a member of Desk and Derrick and of Delta Theta Chi Sorority. Occasionally she takes off a Saturday afternoon and takes in a football game.

The Olson daughters are now old enough to help in the business and they spend a part of their week-ends helping out in the office.

Kay Olson has never been sorry she decided to keep the business. "It's been hard work," she says, "and it's an unusual profession for a woman, I know. But it's fascinating and I've had the satisfaction of seeing it grow. Best of all, the home, education and security my husband would have provided for our children has been insured to them."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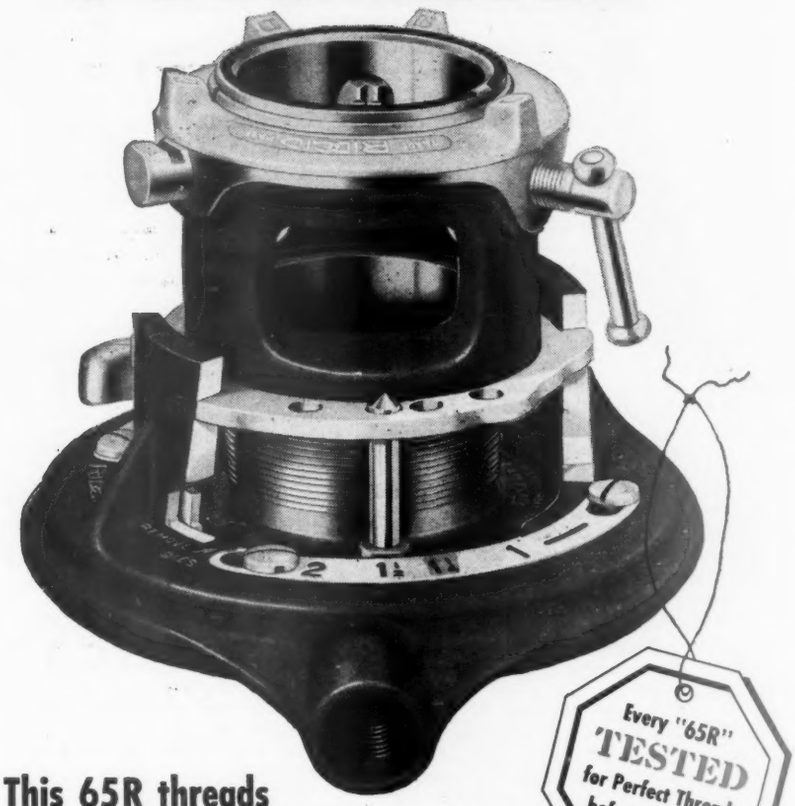


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# PERSONALS

**John Paar, Jr.,** assistant manager of the banking department of Shell Oil Company, has been promoted to manager, succeeding **J. L. Ledger,** who has retired. Paar joined Shell in 1929 as cashier. In 1935, he was appointed chief clerk and five years later came to New York in the same capacity. He was made assistant manager in 1941.

**Douglas Robinson,** Q. C., has been named a vice president of Canadian Oil Companies, Ltd. Robinson originally set up Canadian Oil's legal department and has served in recent years as general counsel and secretary of the company.

**Robert S. Kerr** has been named chairman of the board of Kerr-McGee Oil Industries, Inc. He is a Senator from Oklahoma. **Dean A. McGee,** executive vice president, was named president, and succeeding him is **Travis M. Kerr,** who has been in charge of drilling tools and contracts. **Frank C. Love,** assistant to McGee and company counsel, was elected vice president of all company operations.

**William F. Kirk** has been named assistant director of the Program Division of the Petroleum Administration for Defense. He will be succeeded by **James S. Weatherby,** chief of the Division's Domestic Petroleum Branch since August 10, 1953.

Kirk, who joined the PAD staff last July 16, will return to his position as assistant manager of the economics department, General Petroleum Corporation, Los Angeles, California. Weatherby is on leave from the Atlantic Refining Company.

**Arthur W. Brown** has been named manager of the employee relations department by Esso Standard Oil Company. He succeeds **William B. Maloney** who has joined the parent organization, Standard Oil Company (New Jersey). Brown who has been assistant employee relations manager of the company's Bayway refinery in Linden, New Jersey, previously headed Esso's employee benefit plans and social security division. A graduate of Princeton University in 1940, he joined Standard Jersey in 1946.

**Captain Richard Schwarz,** master of the S. S. David McKelvey and **Captain Stanley Matthews,** master of the S. S. Robert E. Hopkins, retired recently, from Tide Water Associated Oil Company after completing nearly 27 years of service each. Both masters joined the company in 1927.

**Eleven novices were inducted by the Houston, Texas, chapter of Nomads at its March meeting. Inductees, along with three guests, were: Front row: J. W. Wallace, National Tank; A. H. Beal, Oil Well Survey; A. D. Cathey, Cameron Iron; Jack G. Walker, and E. H. Lancaster, Magnet-Cove-Barium; U. V. Seales, Hunt Tool. Back row: R. J. Young, Shell, Houston (visitor); M. T. Childress, Gray Tool; Leslie W. Jones, Baroid Sales Division; Bruce Barkis, B & W Inc.; Laurence B. Murray, Continental Supply; Spencer W. Robinson, *Drilling Magazine*; L. W. Storms, Pantepec Oil, Caracas, Venezuela, and J. N. White, Glenn McCarthy, Inc., Bolivia.**

**Frank V. Martinek** of Chicago, assistant vice president of Standard Oil Company (Indiana) and retired chairman of the Great Lakes district of the Oil Industry Information Committee, has been elected president of the new "OIIC Fellows" national chapter.

Other officers are **John S. Cooke** of New York, secretary, and **Edward C. Belefski** of New York, treasurer. Cooke is secretary and Belefski is comptroller of the national Oil Industry Information Committee.

**T. N. Law, Jr.,** has returned to his duties as industrial relations manager of the Falcon Seaboard Drilling Company. Young Law, stricken by polio last fall, has spent several months in Warm Springs, Georgia, and is now working full time again in the Tulsa main office of Falcon Seaboard.

**A. S. Hanna,** office manager at Joliet, Illinois, for Standard Oil Company, has retired after nearly 44 years' service.

**D. T. Rooney,** formerly office manager at Wichita, Kansas, has been appointed office manager at Joliet, succeeding Hanna. Hanna joined Standard in 1910. He has been office manager at Joliet since 1935.

Rooney joined the company in 1923. Promoted to office manager at Wichita in 1948, he was more recenty assigned to the comptroller's department in the company's general office at Chicago.

**John Sidney Smith** has been appointed public relations representative for Sun Oil Company's production department. Smith, well known Texas newspaperman before joining Sun Oil Company, has been the editor for the last seven years of the company's *Sun Production News*.

**Walter M. Sanford,** assistant editor of *Sun Production News*, succeeds Smith as editor. **Robert J. Wright** becomes the new assistant editor.

**Edward C. Lloyd** has been appointed chief of the Mechanical Instruments Section of the National Bureau of Standards, following the retirement of Dr. W. G. Brombacher. Lloyd has been acting as assistant chief of the Office of Basic Instrumentation at NBS.

In addition to the establishment, maintenance, and improvement of the standards for pressure and humidity, the NBS mechanical instruments program is concerned with improved performance and utilization of sensing elements.

**Frederick G. Coqueron** has been appointed to the official staff of the Chase National Bank of New York as petroleum analyst. A native of New Jersey, Coqueron graduated from Columbia University after serving with the U. S. Army during World War I. In 1923 Coqueron joined Tide Water Associated Oil Company in New York where he remained for 13 years as financial statistician.

**Officers for 1954 of the Los Angeles chapter of Nomads shown at the Fifteenth Annual Inaugural Ball, are: Harry E. Hester, McCullough Tool, secretary; Earle R. Atkins, Emsco Manufacturing, assistant secretary; Robert P. Gaylord, Wagner-Morehouse, deputy sergeant-at-arms; John Flanagan, Johnston Testers, president; H. J. Schlarb, Chiksan, vice president; J. A. Engstrand, master of ceremonies; James D. Hughes, Lane-Wells, junior regent; O. W. Morgan, Jr., Falcon Products, sergeant-at-arms; Leo Cypher, Baash-Ross Tool, treasurer. Not shown, W. A. Wilson, Web Wilson, regent, and Earl V. Tavan, Ken Corp., assistant treasurer.**

## Personals

**John H. Purnell** has been named director of public relations for Cities Service Oil Company. Purnell has been in charge of publications and news since he joined

J. H. Purnell

J. Steiger

the company in 1951. **John Steiger,** editor of *Empire* magazine, will be superintendent of publications and news in the public relations department.

Purnell formerly was editor of the Bartlesville Examiner-Enterprise. Before coming to Bartlesville he was editor of newspapers in Paris, and Marshall, Texas, and was connected with the U. S. Department of Agriculture. He was public relations director of the East Texas Chamber of Commerce from 1926 to 1928. Purnell attended Louisiana Polytechnic Institute, Centenary College, and Louisiana State University.

Steiger has been with Cities Service for 12 years. Before coming with the company he was manager of the Mid-Continent news bureau of the National Petroleum News.

**Selma Erickson, Standard Oil Indiana, new president of Chicago Desk and Derrick Club, and Catherine Connell, The Texas Company, immediate past president.**

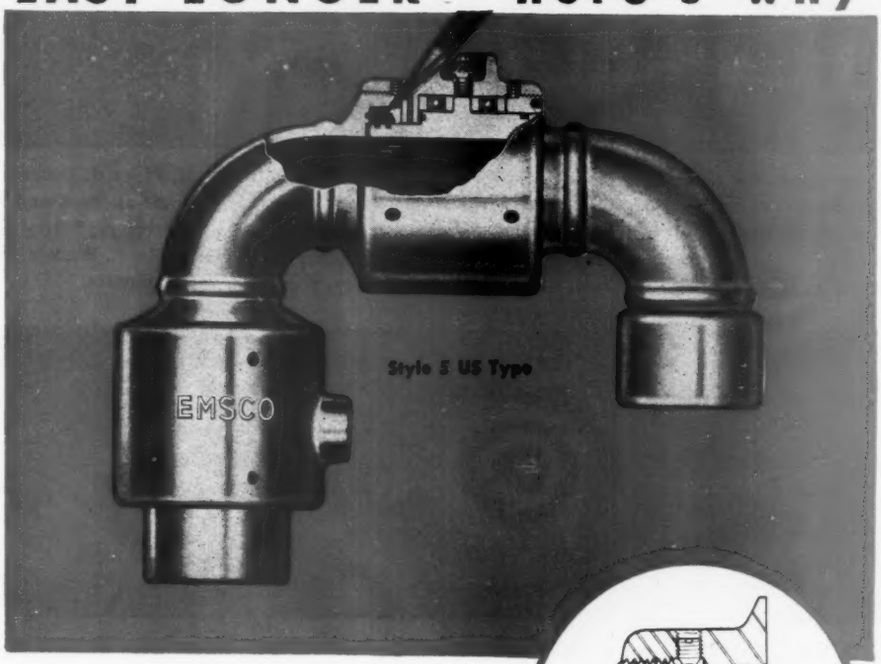
**J. F. Bourke** will succeed **E. E. Kelley,** manager of general office building of Standard Oil Indiana, who has retired after almost 36 years' company service. Bourke joined the company in 1930 as a draftsman at its Whiting, Indiana, refinery. Kelley who was named to his position in 1939, joined the company in 1918 as a clerk in the sales accounting department.

Succeeding Bourke will be **K. H. Shephard** as assistant manager of the general office building. Shephard came with Standard in 1947.

**C. M. Lyon** will succeed **A. K. Hermes** as manager of the capital stock recording division in the secretary's department of Standard of Indiana. Lyon became assistant manager in 1949. He joined the company in 1928. Hermes was made manager of the division in 1946, after having been with Standard since 1918.

Succeeding Lyon will be **Leroy Hoff** as assistant manager. Hoff was former supervisor of the bookkeeping division and joined the company in 1926.


# EMSCO SWIVEL FITTINGS LAST LONGER — here's why



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Type US for high temperature or Corrosive Service.

## UNIQUE DESIGN PERMITS EASY MAINTENANCE WHILE IN OPERATION

Three basic advantages of the Emsco Ball Bearing Swivel Fitting are:

1. FREE TURNING
2. EFFICIENT PACK-OFF
3. LONG LASTING

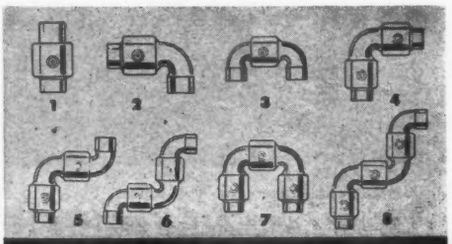
An Emsco Swivel Fitting is practically unexpendable for the reason that, after long service, both the packing and the ball races are easily adjustable and replaceable. This means no discarded fittings—no costly return to the factory for repairs.

Emsco "free turning" Ball Bearing Swivel Fittings are manufactured for almost every type of service, from high vacuum to pressures of 15,000 psi., and from sub-zero temperatures to 750°F. Complete information, prices and delivery upon request.

**Deformable packing extruded into annular grooves assures a positive seal. This Emsco patented method does not affect ease of turning. Any packing material such as asbestos, Blue African Asbestos or Teflon may be used in the US Type fitting.**

**Fittings using a lip type packing are available as Type HS or HP, depending on pressure involved**

LIP TYPE PACKING




8 BASIC STYLES—OVER 500 MODELS

EMSCO

MANUFACTURING COMPANY

BOX 2098, TERMINAL ANNEX

Houston, Texas • LOS ANGELES 54, CALIF. • Garland, Texas

New officers for Houston Nomads are: Robert K. Franklin, Rolo Manufacturing, president; W. O. (Bill) Hedrick, McEvoy, secretary; W. L. (Bill) Childs, Reed Roller Bit, vice president; H. Ben Young, Mission Manufacturing, treasurer; E. M. Fontaine, National Tank, regent; H. J. Wood, Lebanon Steel Foundry, regent; B. H. Pickard, Tuboscope, assistant treasurer; Fred A. Christanelli, sergeant-at-arms, and E. W. Louden, Barold Sales Division, assistant secretary; Harry E. Estes, A-1 Bit and Tool, executive secretary. Otis B. Walker, McCullough Tool, deputy sergeant-at-arms is not in picture.

J. M. Sitler, director of purchases, Esso Standard, who is retiring soon, was the honored guest at the New York Chapter of Nomads' March meeting held at the Hotel Biltmore in New York City. Over two hundred Nomads and their friends were on hand to pay him their respects. In the photograph Sitler (fourth from left) is shown with (left to right) Joe L. Comer, William Powell Company; A. J. Kelly, general purchasing agent, Esso; Ward Casterton, Sitler's predecessor as director of purchases, and Norris L. Boulden, International General Electric, New York Nomad president. Right photo shows visitors at the New York Chapter of Nomads' March 1 party: E. E. Williams, Nomad from Los Angeles; C. R. Zimmerman, Nomad from Tulsa; H. Gruner, Dyckerhoff, Germany, and Don Manson, Compania Shell de Venezuela Ltd., Venezuela.

▸ **C. J. Guzzo** has been elected a vice president of the Gulf Oil Corporation and Gulf Refining Company. He will continue in the domestic marketing department. A veteran of 40 years of service, Guzzo has been division general manager of the company's New Orleans sales territory since 1949. Guzzo first joined Gulf in 1914.

▸ **J. W. Baldwin** has been named manager of a separate department recently organized to handle federal and state income tax matters for Cities Service Oil Company. Such matters have previously been handled by a unit attached to the secretary's division of Cities Service Oil Company.

Baldwin has been connected with income and excise tax units of Cities Service since 1929. He joined the company in 1922 as a junior engineer. He is a graduate mining engineer from the Colorado School of Mines and studied law and accounting in LaSalle Extension University.

▸ **Carroll D. Fentress** has been named assistant deputy administrator for domestic petroleum operations, Petroleum Administration for Defense. He succeeds **John S. Detweiler,** resigned.

Fentress has been with PAD from the beginning and prior to that served with the oil and gas division of the Interior Department. Before entering government service he was with Standard Oil of Indiana for seven years.

Detweiler will return to Standard Oil of California.

▸ **George N. Larson,** purchasing agent, at Houston, Texas, for Standard Oil Company of Texas, is retiring after 40 years of continuous service in the production and purchasing departments. For the last 10 years Larson has been purchasing agent for the production and exploration departments at Houston, Texas. He will continue to reside at Houston.

Howard Slater, purchasing agent, New York purchasing department of the Gulf Oil Corporation, retired, was guest of honor at the New York chapter of Nomads' February meeting held at the Hotel Biltmore in New York City. With him is Norris L. Boulden, president of the New York Nomads, who presented him a receipted bill for a desk which was presented to him for his Florida home.

Visitors at the Nomad meeting: L. L. Rector, Rector Well, Fort Worth; Harry Zane, Guiberson, Dallas; B. F. Caver, Cities Service, Canada; C. S. Pugsley, Esso Standard, Baton Rouge; Augustine Pyre, Danish American Prospecting, Denmark, and Henry W. Pullman, Baker Oil Tools, Los Angeles, California.

## Personals

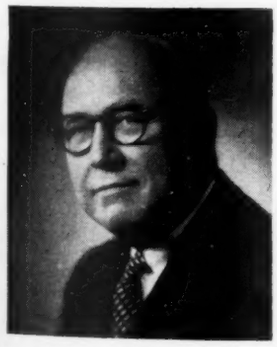
Hal Stewart

**Hal W. Stewart,** assistant general counsel, has been elected to the board of directors and appointed general counsel, of Ohio Oil Company. He succeeds **A. M. Gee,** who has been with Ohio for almost 34 years.

Gee joined Ohio in 1920, handling the company's legal affairs in the Rocky Mountain area at Casper, Wyoming. After attending Miami University Academy and Miami University, Oxford, Ohio, Gee transferred to the University of Chicago Law School in 1912, where he received his doctor's degree.

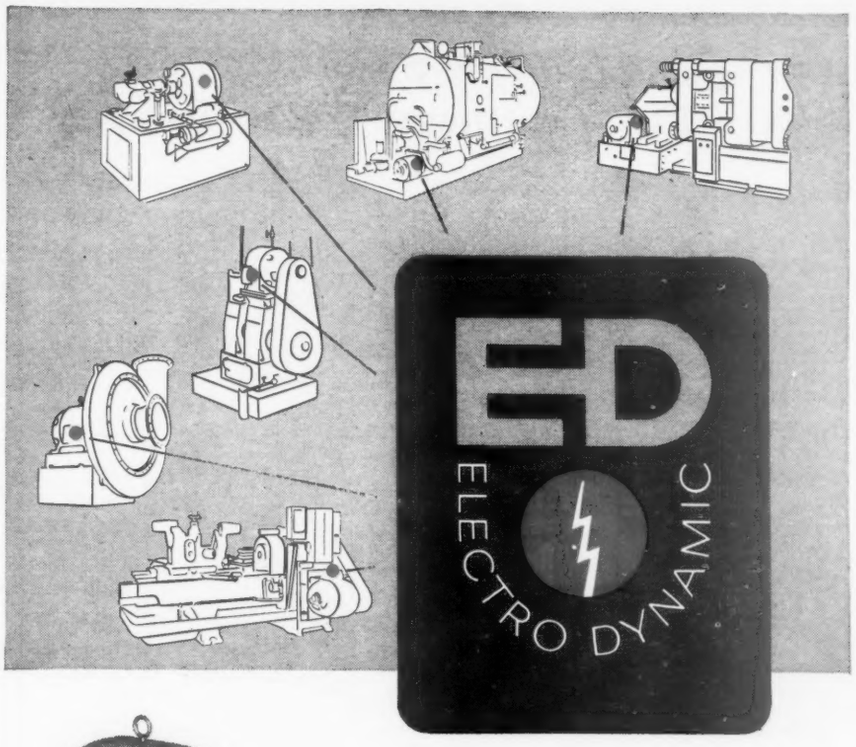
Stewart joined Ohio Oil in 1922 as attorney at Shelby, Montana. He was transferred to Casper, Wyoming, two years later as assistant division attorney. He was appointed assistant general counsel in January 1950. Stewart attended Montana State College at Bozeman and the University of Virginia at Charlottesville.

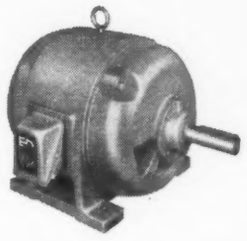
Harry Jeffries



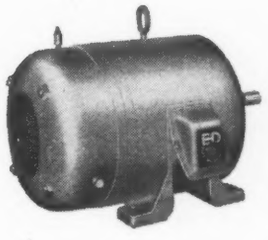
S. H. McManus

**Harry Jeffries,** since 1950 comptroller of Sinclair Oil Corporation, has been elected vice president of the corporation, it was announced by P. C. Spencer, president. **S. H. McManus,** formerly assistant comptroller, has been elected comptroller to succeed Jeffries, while **O. P. Thomas** has been named assistant comptroller, succeeding McManus. Jeffries, who joined Sinclair in 1919, has served as comptroller and director of Sinclair Refining.

**THIS EMBLEM IDENTIFIES EXTRA DEPENDABLE INDUSTRIAL MACHINERY**



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Conclusive evidence of the *extra dependability* of Electro Dynamic motors is now revealed in the new candid report **"MOTOR SHOWDOWN".** The revealing proof is found in *comparative tests** conducted in accordance with A.I.E.E. standards. Don't miss your copy! Send the coupon below *today.*

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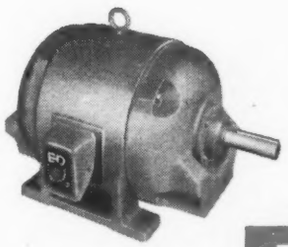

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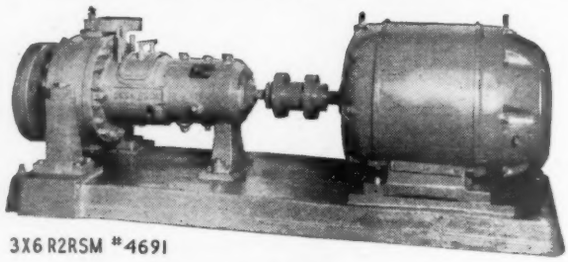
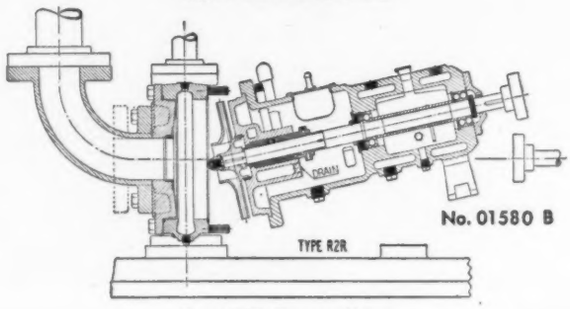
# DEAN BROTHERS PUMPS INC.

## Type R2R Centrifugal Process Pumps




Type R2R Process Pump




Type R2R Process Pump

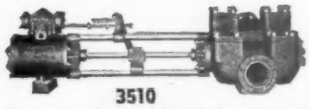
**DISASSEMBLY:** The Type R2R process pumps can be disassembled without disconnecting the suction and discharge piping. By first removing the spacer from the spacer type coupling, and unbolting the casing from the cradle the entire cradle and complete rotating element can be removed without disturbing the suction and discharge piping.

**OPERATING RANGE:** Type R2R, Heavy duty, process pumps are available in eighteen different sizes, enabling our engineers to furnish units specially designed and constructed for the particular work to be performed.
Capacities: 50 to 2000 Gallons per minute.
Heads: Up to 400'. Speeds: 900 RPM to 4000 RPM.

*BUILDERS OF OUTSTANDING PUMPS SINCE 1869*

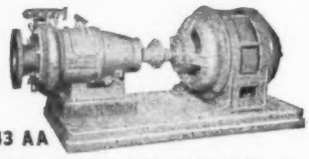
**CENTRIFUGAL AND RECIPROCATING PUMPS**

Close Coupled Centrifugal Pump



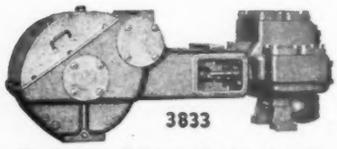
3510

Horizontal, Single Style, Double Acting, Piston Type, Close Clearance Pump. Designed to handle volatile liquids



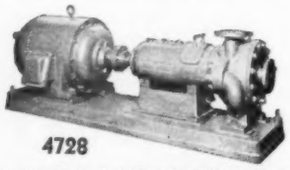
4043 AA

Pedestal Mounted Centrifugal Pump



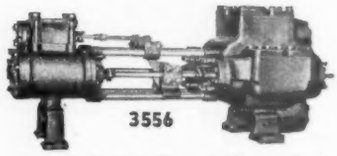
3833

Horizontal, Duplex, Double Acting, Side Pot, Piston Type, Oil Bath Power Pump



4728

Double Pedestal Bearing Centrifugal Pump



3556

Durable Duplex Packed Piston Pattern Steam Pump, Side Pot Type

ESTABLISHED 1869

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# DEATHS

**Charles E. Maschal,** manager of Sun Oil Company's Marcus Hook refinery, died February 17 at his home, Swarthmore, Pennsylvania, following a sudden heart attack. He was 47.

Presumably in good health, he had recently returned from a vacation. Maschal joined Sun as a still fireman at Marcus Hook refinery and, following a series of advancements, became manager of the refinery in 1951. He was a graduate of Drexel Institute.

**A. Ludlow Clayden,** former head of Sun Oil Company's Automotive Laboratory at Marcus Hook, Pennsylvania, died in Halifax Hospital, Daytonia Beach, Florida, February 23. An authority on fuels and internal combustion engines, Clayden retired last July after 31 years with Sun Oil Company. Born in Bath, England, in 1883, Clayden studied at Bristol University in Bristol, England. In England he was associated with Daimler Motor Company, and worked as consulting engineer for Wright-Martin Aircraft Corporation in Europe. Immediately prior to joining Sun he was general consultant to the United States Cartridge Company in Lowell, Massachusetts.

**Errol J. Hesser,** district superintendent of the Southern district for the British-American Oil Producing Company, was fatally injured in an automobile accident in Houston on March 3. Hesser's career in the oil industry has been a colorful one. He began as a summertime roustabout when he was attending Humble High School at Humble, Texas. He later worked for several drilling companies and, in 1917, became a land scout for Sun Oil. Two years later he joined Monarch Oil and Refining. After five years with Monarch, he became connected with Vacuum Oil Company. He then worked for Barkley and Meadows Company for four years and in 1930, went with Pure. He joined British-American in 1948.

**Dr. Frank Wenner,** an internationally known physicist and geo-physicist, died on February 7, following a stroke. Dr. Wenner had been active in consulting work at the National Bureau of Standards up to the time of his death. He was 81.

Dr. Wenner had been chief of the Resistance Measurements Section of NBS for 30 years when he retired in 1943 and a member of the staff for 36 years.

**Hunter W. Pryor,** manager of the tax and insurance department, Arkansas Fuel Oil Corporation, died recently at his home in Shreveport, Louisiana.

He was past chairman of Mid-Continent Oil and Gas Association. He joined Louisiana Oil Refining Corporation, a predecessor company of Arkansas Fuel Oil, in Little Rock, and last December, completed 25 years of service with this company.

**W. B. Martin,** president of the Martin-Ireland Oil Company, Wichita Falls, Texas, died of a heart attack at his resort home on Possum Kingdom Lake, February 23. He was the son of the late M. L. Martin and Mrs. Martin.

**Lester T. Burns, Sr.,** independent producer, died as a result of an automobile accident on March 17, near Henrietta, Texas. Burns' home was in Wichita Falls, Texas. He was 60 years of age.

## SAFETY FACTOR VS. DEPTH

1¼-IN. DIAMETER 6 X 19 SEALE IMPROVED PLOW STEEL FIBER CORE. BREAKING STRENGTH = 64.6 TONS.

### SAFETY FACTORS WITH 4½-IN., 16.6-LBS. DRILL PIPE

| DEPTH, FT. | WEIGHT DRILL PIPE IN MUD, LBS. | TRAVELING BLOCK ASSEMBLY, LBS. | TOTAL HOOK LOAD, LBS. | 6 LINES | | 8 LINES | | 10 LINES | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | FAST LINE LOAD, LBS. | FACTOR OF SAFETY | FAST LINE LOAD, LBS. | FACTOR OF SAFETY | FAST LINE LOAD, LBS. | FACTOR OF SAFETY |
| 1,000 | 15,000 | 25,000 | 40,000 | 7,630 | 16.8 | 5,950 | 21.7 | 4,940 | 26.2 |
| 2,000 | 30,000 | 25,000 | 55,000 | 10,500 | 12.9 | 8,180 | 15.8 | 6,800 | 19.0 |
| 3,000 | 45,000 | 25,000 | 70,000 | 13,400 | 9.65 | 10,400 | 12.4 | 8,650 | 14.9 |
| 4,000 | 60,000 | 25,000 | 85,000 | 16,200 | 8.0 | 12,600 | 10.2 | 10,500 | 12.3 |
| 5,000 | 75,000 | 25,000 | 100,000 | 19,100 | 6.76 | 14,800 | 8.72 | 12,300 | 10.5 |
| 6,000 | 90,000 | 25,000 | 115,000 | 22,000 | 5.87 | 17,100 | 7.55 | 14,200 | 9.1 |
| 7,000 | 105,000 | 25,000 | 130,000 | 24,800 | 5.22 | 19,300 | 6.7 | 16,000 | 8.1 |
| 8,000 | 120,000 | 25,000 | 145,000 | 27,700 | 4.66 | 21,500 | 6.0 | 17,900 | 7.22 |
| 9,000 | 135,000 | 25,000 | 160,000 | 30,600 | 4.22 | 23,800 | 5.43 | 19,800 | 6.52 |
| 10,000 | 150,000 | 25,000 | 175,000 | 33,400 | 3.87 | 26,000 | 4.97 | 21,600 | 5.98 |
| 11,000 | 165,000 | 25,000 | 190,000 | 36,300 | 3.56 | 28,300 | 4.56 | 23,400 | 5.52 |
| 12,000 | 180,000 | 25,000 | 205,000 | 39,200 | 3.3 | 30,500 | 4.22 | 25,300 | 5.1 |
| 13,000 | 195,000 | 25,000 | 220,000 | 42,000 | 3.08 | 32,700 | 3.95 | 27,200 | 4.75 |
| 14,000 | 210,000 | 25,000 | 235,000 | 44,800 | 2.88 | 35,000 | 3.69 | 29,100 | 4.44 |
| 15,000 | 225,000 | 25,000 | 250,000 | 47,700 | 2.71 | 37,200 | 3.48 | 30,800 | 4.20 |

1¼-IN. DIAMETER 6 X 19 SEALE IMPROVED PLOW STEEL IWRC. BREAKING STRENGTH = 69.4 TONS.

### SAFETY FACTORS WITH 4½-IN., 16.6-LBS. DRILL PIPE

| DEPTH, FT. | WEIGHT DRILL PIPE IN MUD, LBS. | TRAVELING BLOCK ASSEMBLY, LBS. | TOTAL HOOK LOAD, LBS. | 6 LINES | | 8 LINES | | 10 LINES | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | FAST LINE LOAD, LBS. | FACTOR OF SAFETY | FAST LINE LOAD, LBS. | FACTOR OF SAFETY | FAST LINE LOAD, LBS. | FACTOR OF SAFETY |
| 1,000 | 15,000 | 25,000 | 40,000 | 7,630 | 18.19 | 5,950 | 23.33 | 4,940 | 28.10 |
| 2,000 | 30,000 | 25,000 | 55,000 | 10,500 | 13.22 | 8,180 | 16.97 | 6,800 | 20.41 |
| 3,000 | 45,000 | 25,000 | 70,000 | 13,400 | 10.36 | 10,400 | 13.35 | 8,650 | 16.05 |
| 4,000 | 60,000 | 25,000 | 85,000 | 16,200 | 8.57 | 12,600 | 11.01 | 10,500 | 13.22 |
| 5,000 | 75,000 | 25,000 | 100,000 | 19,100 | 7.27 | 14,800 | 9.38 | 12,300 | 11.28 |
| 6,000 | 90,000 | 25,000 | 115,000 | 22,000 | 6.31 | 17,100 | 8.12 | 14,200 | 9.77 |
| 7,000 | 105,000 | 25,000 | 130,000 | 24,800 | 5.60 | 19,300 | 7.19 | 16,000 | 8.67 |
| 8,000 | 120,000 | 25,000 | 145,000 | 27,700 | 5.01 | 21,500 | 6.46 | 17,900 | 7.75 |
| 9,000 | 135,000 | 25,000 | 160,000 | 30,600 | 4.54 | 23,800 | 5.83 | 19,800 | 7.01 |
| 10,000 | 150,000 | 25,000 | 175,000 | 33,400 | 4.16 | 26,000 | 5.34 | 21,600 | 6.43 |
| 11,000 | 165,000 | 25,000 | 190,000 | 36,300 | 3.82 | 28,300 | 4.90 | 23,400 | 5.93 |
| 12,000 | 180,000 | 25,000 | 205,000 | 39,200 | 3.54 | 30,500 | 4.55 | 25,300 | 5.49 |
| 13,000 | 195,000 | 25,000 | 220,000 | 42,000 | 3.30 | 32,700 | 4.24 | 27,200 | 5.10 |
| 14,000 | 210,000 | 25,000 | 235,000 | 44,800 | 3.10 | 35,000 | 3.97 | 29,100 | 4.77 |
| 15,000 | 225,000 | 25,000 | 250,000 | 47,700 | 2.91 | 37,200 | 3.73 | 30,800 | 4.51 |

*Courtesy of Wickwire Rope, The Colorado Fuel and Iron Corporation*

# TEFLON GASKETS

## make a difference in performance!

By equipping every a.c.f. Lubricated Plug Valve with the new Teflon Gasket, we have lengthened service life while improving operation.

You get greater protection against head leakage... trouble-free operation in temperatures up to 450° F. Greatly reduced turning torque.

What's more, this new gasket—tested in the field for four years under the most exacting conditions—is a discovery that can mean substantial savings in time and money. Investigate today! See your a.c.f. Representative for the complete facts.

Gasket characteristics:

- self lubricating
- can't bind
- unique shape maintains lubricant release
- pressure tight

Round Port Valves–100% Obstruction Free • Rectangular Port Valves with Full Pipe Area • Venturi Valves for Economy

a.c.f. CYLINDRICAL FULL PIPE AREA

Representatives in 50 Principal Cities

# PLUG VALVES

Write for Catalog No. 4-PE and Price List. American Car and Foundry Company, Valve Division, 1501 E. Ferry Avenue, Detroit 11, Michigan

# UNIVERSAL CONVERSION FACTORS

## ACRE =

| | |
|---|---|
| 0.0015625 | square miles or sections |
| 0.004046875 | square kilometers |
| 0.1 | square furlongs |
| 0.4046875 | square hektometers |
| 10 | square chains |
| 40.46875 | square dekameters |
| 160 | square rods |
| 4,046.875 | square meters |
| 4,840 | square yards |
| 5,645.41213 | square varas (Texas) |
| 43,560 | square feet |
| 77,440 | square spans |
| 100,000 | square links |
| 400,000 | square hands |
| 404,687.5 | square decimeters |
| 40,468.750 | square centimeters |
| 6,272,640 | square inches |
| 4,046,875,000 | square millimeters |
| 0.4046875 | hectares |
| 40.46875 | ares |
| 4,046.875 | centares (centiares) |

## ACRE FOOT =

| | |
|---|---|
| 1,233.48766 | kiloliters |
| 1,233.48766 | cubic meters |
| 1,633.3333 | cubic yards |
| 43,560 | cubic feet |
| 7,758.34 | barrels |
| 12,334.8766 | hektoliters |
| 35.000 | bushels — U. S. (dry) |
| 33,933.16195 | bushels — Imperial (dry) |
| 123,348.766 | dekaliters |
| 140,000 | pecks |
| 325,850.28 | gallons — U. S. (liquid) |
| 280,092.5925 | gallons — U. S. (dry) |
| 271,325.745265 | gallons — Imperial |
| 1,303,401.12 | quarts (liquid) |
| 1,120,370.370 | quarts (dry) |
| 1,233,487.66 | liters |
| 1,233,487.660 | cubic decimeters |
| 2,606,802.24 | pints |
| 10,427,208.96 | gills |
| 12,334,876.6 | deciliters |
| 75,271,680 | cubic inches |
| 123,348,766 | centiliters |
| 1,233,487,660 | milliliters |
| 1,233,487,660 | cubic centimeters |
| 1,233,487,660,000 | cubic millimeters |

## ACRE FOOT PER DAY =

| | |
|---|---|
| 7,758.34 | barrels per day |
| 323.264167 | barrels per hour |
| 5.387736 | barrels per minute |
| 0.0897956 | barrels per second |
| 325,850.28 | gallons (U. S.) per day |
| 13,577.09400 | gallons (U. S.) per hour |
| 226.284900 | gallons (U. S.) per minute |
| 3.771415 | gallons (U. S.) per second |
| 271,325.745265 | gallons (Imperial) per day |
| 11,305.238400 | gallons (Imperial) per hour |
| 188.42066 | gallons (Imperial) per minute |
| 3.140344 | gallons (Imperial) per second |
| 1,233.48766 | cubic meters per day |
| 51.395319 | cubic meters per hour |
| 0.856589 | cubic meters per minute |
| 0.0142765 | cubic meters per second |
| 1,633.33333 | cubic yards per day |
| 68.0555552 | cubic yards per hour |
| 1.134259 | cubic yards per minute |
| 0.0189043 | cubic yards per second |
| 43,560 | cubic feet per day |
| 1,815.0 | cubic feet per hour |
| 30.25000 | cubic feet per minute |
| 0.504167 | cubic feet per second |
| 75,271,680.00 | cubic inches per day |
| 3,136,320.00 | cubic inches per hour |
| 52,272 00 | cubic inches per minute |
| 871.200 | cubic inches per second |

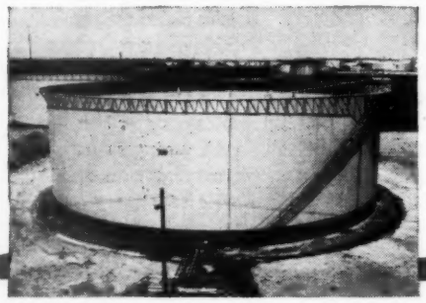
## ATMOSPHERE =

| | |
|---|---|
| 0.103327 | hektometers of water @ 60° F. |
| 1.03327 | dekameters of water @ 60° F. |
| 10.3327 | meters of water @ 60° F. |
| 33.9007 | feet of water @ 60° F. |
| 406.8084 | inches of water @ 60° F. |
| 103.327 | decimeters of water @ 60° F. |
| 1,033.27 | centimeters of water @ 60° F. |
| 10,332.7 | millimeters of water @ 60° F |
| 0.00760 | hektometers of mercury @ 32° F. |
| 0.0760 | dekameters of mercury @ 32° F. |
| 0.760 | meters of mercury @ 32° F. |
| 2.49343 | feet of mercury @ 32° F. |
| 29.9212 | inches of mercury @ 32° F. |
| 7.6 | decimeters of mercury @ 32° F. |
| 76 | centimeters of mercury @ 32° F. |
| 760 | millimeters of mercury @ 32° F. |
| 113,893.88 | tons per square hektometer |
| 1,138.9388 | tons per square dekameter |
| 11.389388 | tons per square meter |
| 1.0581 | tons per square foot |
| 0.00734792 | tons per square inch |
| 0.11389388 | tons per square decimeter |
| 0.0011389388 | tons per square centimeter |
| 0.000011389388 | tons per square millimeter |
| 103,327,000 | kilograms per square hektometer |
| 1,033,270 | kilograms per square dekameter |
| 10,322.7 | kilograms per square meter |
| 959.931252 | kilograms per square foot |
| 6.666189 | kilograms per square inch |
| 103.327 | kilograms per square deicmeter |
| 1.03327 | kilograms per square centimeter |
| 0.0103327 | kilograms per square millimeter |
| 227,774,851.2 | pounds per square hektometer |
| 2,277,748.512 | pounds per square dekameter |
| 22,777.48512 | pounds per square meter |
| 2,116.080 | pounds per square foot |
| 14.696 | pounds per square inch |
| 227.7748512 | pounds per square decimeter |
| 2.277748512 | pounds per square centimeter |
| 0.02277748512 | pounds per square millimeter |
| 1,033,270,000 | hektograms per square hektometer |
| 10,332,700 | hektograms per square dekameter |
| 103,327 | hektograms per square meter |
| 9,599.31252 | hektograms per square foot |

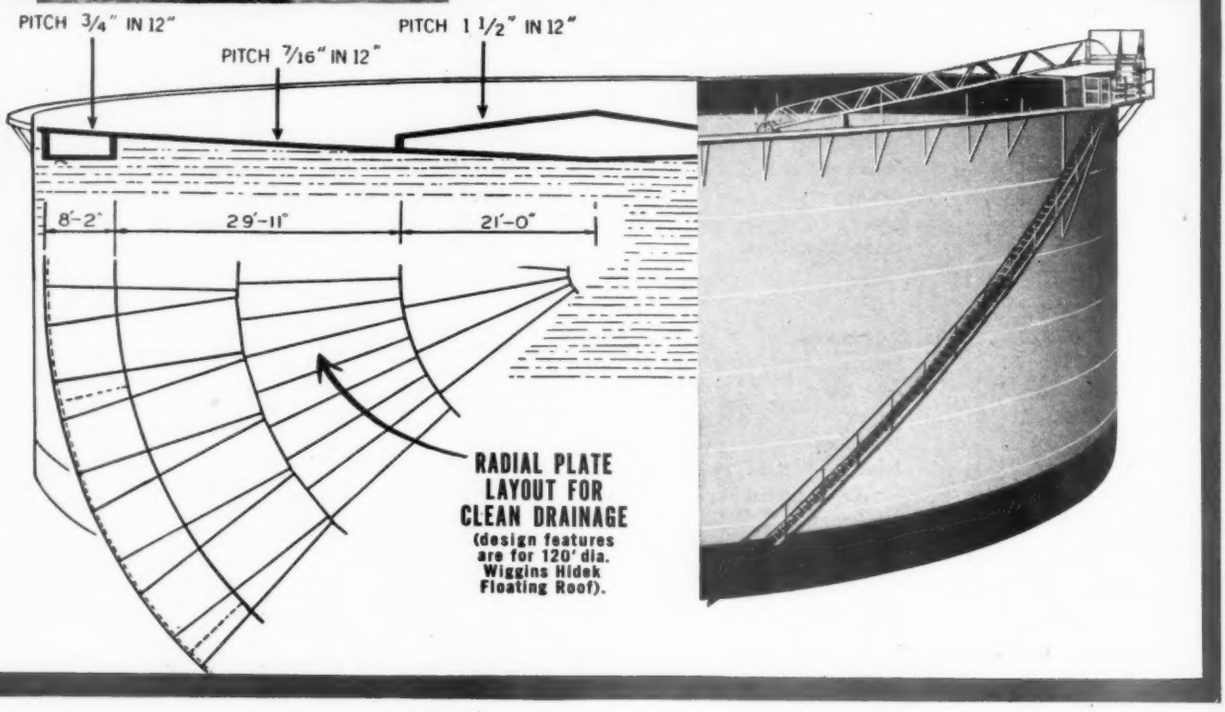
*Compiled by Steven Gerolde, Gulf Oil Corporation*

*the important factors in* **floating roof design**

number 5 of a series



# Strength for all-weather safety


PITCH 3/4" IN 12"
PITCH 7/16" IN 12"
PITCH 1 1/2" IN 12"
8'-2"
29'-11"
21'-0"
RADIAL PLATE LAYOUT FOR CLEAN DRAINAGE
(design features are for 120' dia. Wiggins Hidek Floating Roof).

A floating roof must be designed and built to withstand extreme deck loads and stresses without buckling or loss of buoyancy.

The outer pontoon must be divided into separate sealed compartments so that even flooding of several compartments cannot affect performance of the roof. It must float under such unusual circumstances as failure of roof to drain, deck leaks, or unevenly distributed snow loads.

Wiggins floating roofs include all these important strength and buoyancy features.

## OTHER VITAL WIGGINS CONSERVATION AND SAFETY FEATURES

**Triple Seal Protection**
- Exclusive primary, secondary and top seals conserve more vapors than those of any other type floating roof.

**Drainage**
- Complete, clean drainage assures protection against peeling of paint, rusting and dangerous accumulation of water.

**Capacity**
- You get top-to-bottom use of tank capacity.

**Pontoons**
- Deep and roomy, uncluttered with framework—for easy inspection, maintenance and repair.

## Only Wiggins floating roofs meet every important design specification

WIGGINS VAPOR SEALS GENERAL AMERICAN TRADE MARK

**GENERAL AMERICAN TRANSPORTATION CORPORATION**
135 South LaSalle Street • Chicago 90, Illinois

# UNIVERSAL CONVERSION FACTORS

## ATMOSPHERE (Continued) =

| | |
|---|---|
| 66.66189 | hektograms per square inch |
| 1,033.27 | hektograms per square decimeter |
| 10.3327 | hektograms per square centimeter |
| 0.103327 | hektograms per square millimeter |
| 10,332,700,000 | dekagrams per square hektometer |
| 103,327,000 | dekagrams per square dekameter |
| 1,033,270 | dekagrams per square meter |
| 95,993.1252 | dekagrams per square foot |
| 666.6189 | dekagrams per square inch |
| 10,332.7 | dekagrams per square decimeter |
| 103.327 | dekagrams per square centimeter |
| 1.03327 | dekagrams per square millimeter |
| 3,644,397,619.2 | ounces per square hektometer |
| 36,443,976.192 | ounces per square dekameter |
| 364,439.76192 | ounces per square meter |
| 33,857.28 | ounces per square foot |
| 235.136 | ounces per square inch |
| 3,644.39762 | ounces per square decimeter |
| 36.44398 | ounces per square centimeter |
| 0.36444 | ounces per square millimeter |
| 103,327,000,000 | grams per square hektometer |
| 1,033,270,000 | grams per square dekameter |
| 10,322,700 | grams per square meter |
| 959,931.252 | grams per square foot |
| 6,666.189 | grams per square inch |
| 103,327 | grams per square decimeter |
| 1,033.27 | grams per square centimeter |
| 10.3327 | grams per square millimeter |
| 1,033,270,000,000 | decigrams per square hektometer |
| 10,332,700,000 | decigrams per square dekameter |
| 103,327,000 | decigrams per square meter |
| 9,599,312.52 | decigrams per square foot |
| 66,661.89 | decigrams per square inch |
| 1,033,270 | decigrams per square decimeter |
| 10,332.7 | decigrams per square centimeter |
| 103.327 | decigrams per square millimeter |
| 10,332,700,000,000 | centigrams per square hektometer |
| 103,327,000,000 | centigrams per square dekameter |
| 1,033,270,000 | centigrams per square meter |
| 95,933,125.2 | centigrams per square foot |
| 666,618.9 | centigrams per square inch |
| 10,332,700 | centigrams per square decimeter |
| 103,327 | centigrams per square centimeter |
| 1,033.270 | centigrams per square millimeter |
| 103,327,000,000,000 | milligrams per square hektometer |
| 1,033,270,000,000 | milligrams per square dekameter |
| 10,332,700,000 | milligrams per square meter |
| 959,931,252 | milligrams per square foot |
| 6,666,189 | milligrams per square inch |
| 103,327,000 | milligrams per square decimeter |
| 1,033,270 | milligrams per square centimeter |
| 10,332.7 | milligrams per square millimeter |
| 101,325,000,000,000 | dynes per square hektometer |
| 1,013,250,000,000 | dynes per square dekameter |
| 10,132,500,000 | dynes per square meter |
| 941,343,587 | dynes per square foot |
| 6,537,096 | dynes per square inch |
| 101,325,000 | dynes per square decimeter |
| 1,013,250 | dynes per square centimeter |
| 10,132.5 | dynes per square millimeter |
| 1.01325 | bars |

## BARREL =

| | |
|---|---|
| 0.158987 | kiloliters |
| 0.158987 | cubic meters |
| 0.20794 | cubic yards |
| 1.58987 | hectoliters |
| 4.511274 | bushels — U. S. (dry) |
| 4.373766 | bushels — Imperial (dry) |
| 5.6146 | cubic feet |
| 15.89871 | dekaliters |
| 18.045097 | pecks |
| 42 | gallons — U. S. (liquid) |
| 36.09798 | gallons — U. S. (dry) |
| 34.99089 | gallons — Imperial |
| 168 | quarts (liquid) |
| 144.408516 | quarts (dry) |
| 158.987146 | liters |
| 158.987146 | cubic decimeters |
| 336 | pints |
| 1,344 | gills |
| 1,589.87146 | deciliters |
| 9,702.0288 | cubic inches |
| 15,898.71459456 | centiliters |
| 158,987.1459456 | milliliters |
| 158,987.1459456 | cubic centimeters |
| 158,987,145.9456 | cubic millimeters |
| 0.174993 | tons (short) of water @ 62° F. |
| 0.1562438 | tons (long) of water @ 62° F. |
| 0.1587512 | tons (metric) of water @ 62° F. |
| 158.7512 | kilograms of water @ 62° F. |
| 349.986 | pounds of water @ 62° F. |
| 15.87512 | hektograms of water @ 62° F. |
| 1.587512 | dekagrams of water @ 62° F. |
| 5,599.776 | ounces of water @ 62° F. |
| 0.1587512 | grams of water @ 62° F. |
| 0.01587512 | decigrams of water @ 62° F. |
| 0.001587512 | centigrams of water @ 62° F. |
| 0.0001587512 | milligrams of water @ 62° F. |
| 5.1042 | sacks of cement |
| 2,449,902 | grains |
| 404.25 | pounds of salt water @ 60° F. of 1.155 specific gravity |

## BARREL OF CEMENT =

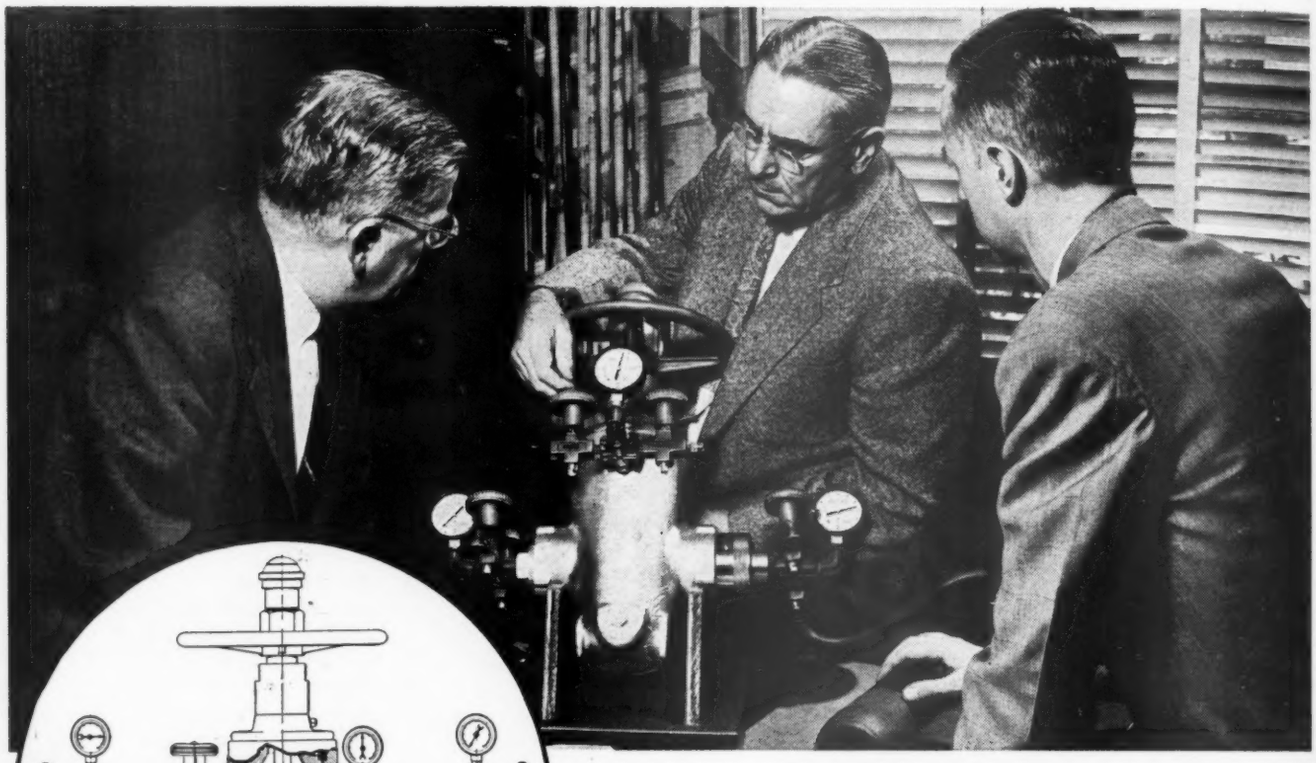
| | |
|---|---|
| 0.158987 | kiloliters |
| 0.158987 | cubic meters |
| 0.20794 | cubic yards |
| 1.58987 | hectoliters |
| 4.511274 | bushels — U. S. (dry) |
| 4.373766 | bushels — Imperial (dry) |
| 5.6146 | cubic feet |
| 15.89871 | dekaliters |
| 18.045097 | pecks |
| 42 | gallons — U. S. (liquid) |
| 36.10213 | gallons — U. S. (dry) |
| 34.99089 | gallons — Imperial |
| 168 | quarts (liquid) |
| 144.408516 | quarts (dry) |
| 158.987146 | liters |
| 158.987146 | cubic decimeters |
| 336 | pints |
| 1,344 | gills |
| 1,589.87146 | deciliters |
| 9,702.0288 | cubic inches |
| 15,898.71459456 | centiliters |

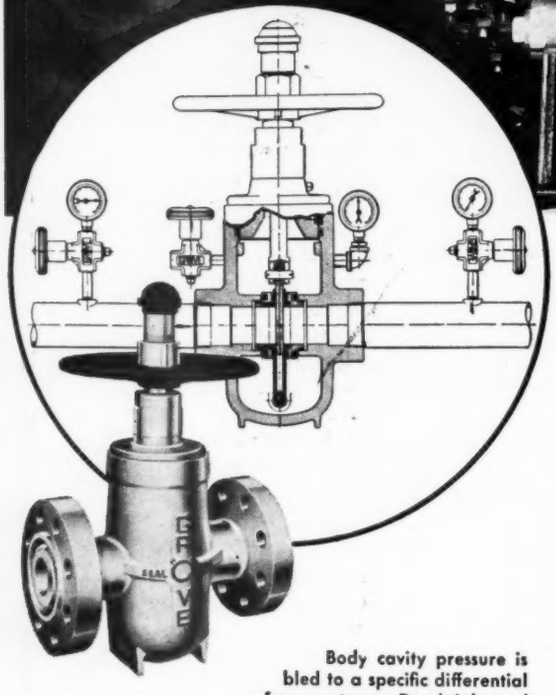
*Compiled by Steven Gerolde, Gulf Oil Corporation*



XUM

# WE'LL MAKE THIS TEST WHEREVER YOU SUGGEST






Body cavity pressure is bled to a specific differential from upstream. Dead-tight seal is verified by non-variance of cavity pressure gauge.

*The only gate valve you can check in the line—any time.*

**SEE FOR YOURSELF HOW GROVE SEAL-"O"-RING GATE VALVES CAN BE CHECKED IN THE LINE...for positive dead-tight seal and free-moving gate action**

Your Grove sales engineer is equipped to demonstrate this new field method of testing and checking the dead-tight seal and free-moving gate action of Grove Seal-"O"-Ring Gate Valves—*right in your office*, or wherever you suggest. Simulating actual conditions, this test proves conclusively that Grove Seal-"O"-Ring Valves hold tight as a line blind, yet permit free movement of the hand-wheel at all times. Also, excess body cavity pressure is automatically relieved *internally* to the upstream line by piston-action of Seal-"O"-Ring seat assemblies, actuated by pressure differential. This test set-up shows how you can install this system for checking Grove valves right in the line—at any-time—without loss of gas or liquid. You must see it—to believe it. Contact your nearest Grove District Office today, to arrange for test demonstration.

## GROVE SEAL-"O"-RING Gate Valves

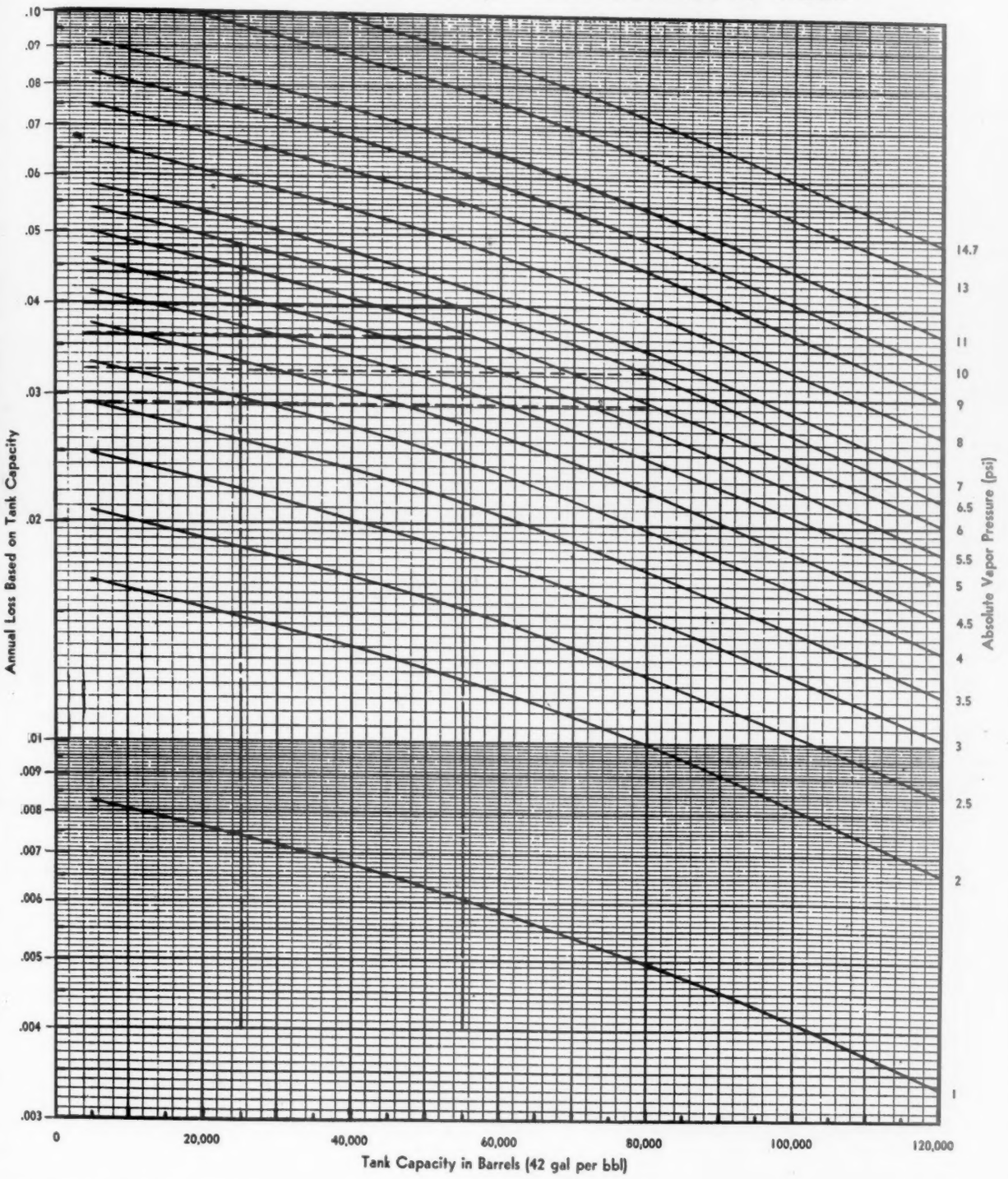
**GROVE REGULATOR COMPANY • 65th & Hollis Sts., Oakland 8, California**

**HOUSTON 4**—1901 Calumet St. • **LOS ANGELES 14**—649 So. Olive St. • **NEW YORK 17**—415 Lexington Ave.

GROVE SIMPLICITY ACCURACY SAFETY

| CORPUS CHRISTI, TEXAS | ODESSA, TEXAS | DALLAS, TEXAS | TULSA, OKLAHOMA | LAFAYETTE, LA. | SHREVEPORT, LA. | NEW ORLEANS, LA. | DENVER, COLO. |
|---|---|---|---|---|---|---|---|
| 4534 No. Baldwin Blvd. | 2604 Kermit Hwy. | 1334 Fidelity Union Life Bldg. | 318 Thompson Bldg. | 101 Berkeley St. | 3727 Greenway Pl. | 331 Sena Drive | 2669 Cherry St. |

# AVERAGE STANDING LOSSES FROM CONE ROOF TANKS




EXAMPLE: A 9 lb Reid Gasoline stored at an average atmospheric temperature of 67.5 F. Liquid Surface Temperature = 77.5 F. Absolute Vapor Pressure = 6.5 psia.

Loss from 55,000 bbl. tank = .039 of capacity per year. Loss = .039 x 55,000 x 42 = 90,000 gal per yr = 2140 bbl per yr.

LIMITATIONS: 1. Aluminum painted standard size tanks, half full.
2. Thermal expansion of vapor space assumed as 20%.
3. Based on average of available test data.

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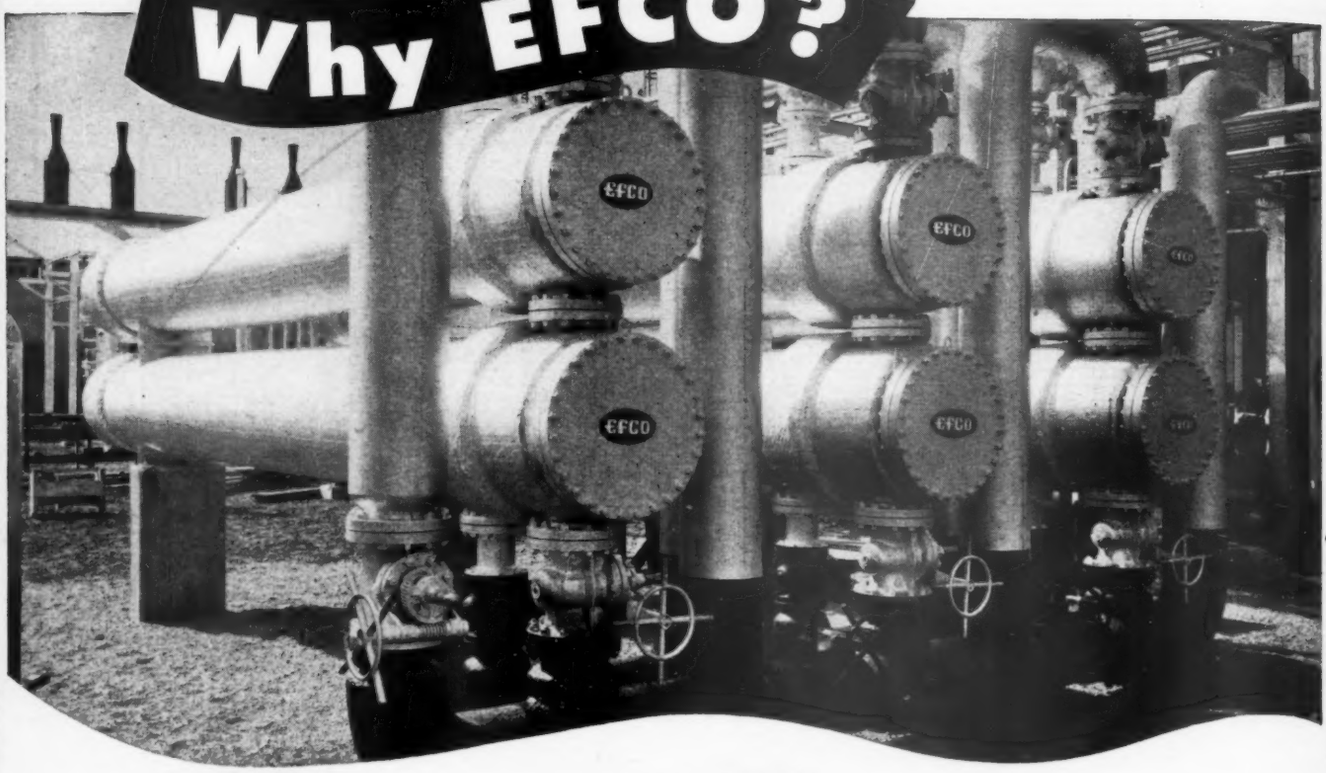
# Why EFCO?

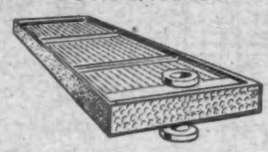



# *Performance* is the answer!

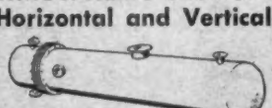
HEAT EXCHANGERS

REBOILERS

CONDENSERS



ATMOSPHERIC SECTIONS
(Horizontal and Vertical)



STEAM GENERATORS

JACKET WATER COOLERS

With the installation of EFCO heat transfer units in your plant, you will be sure of getting *guaranteed performance* with the extra advantages of low maintenance cost, high operating efficiency, long life and freedom from leaks.

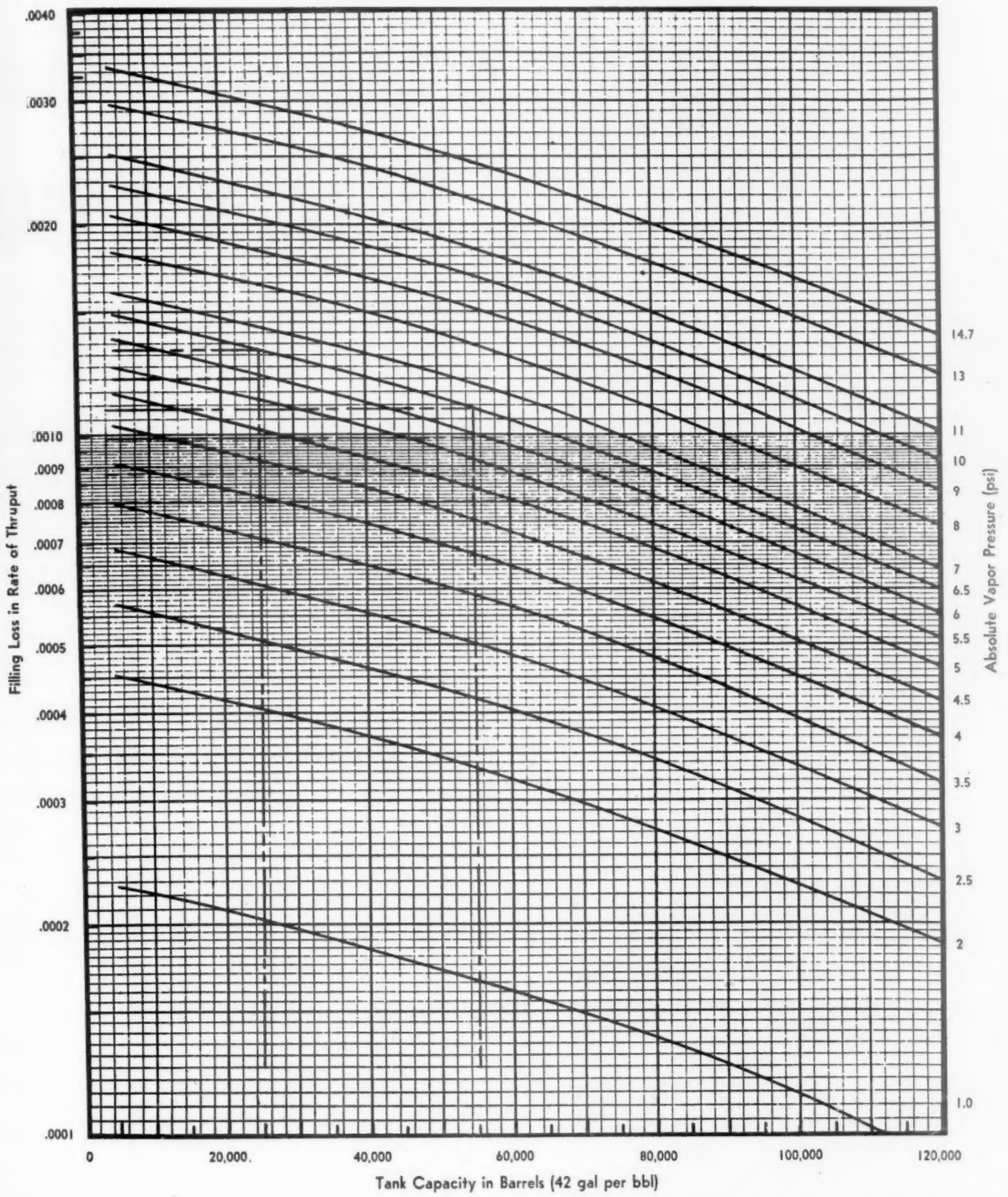
Talk over your heat transfer problems with an EFCO engineer. He will tell you about EFCO installations that have successfully solved problems similar to yours and explain how EFCO equipment will give you the performance you want.

ENGINEERS & FABRICATORS, INC.
P. O. Box 7395 Houston 8, Texas

**EFCO**

**HEAT TRANSFER EQUIPMENT**

## AVERAGE FILLING LOSSES FROM CONE ROOF TANKS




**EXAMPLE:** A 9 lb Reid Gasoline stored at an average atmospheric temperature of 67.5 F. Liquid Surface Temperature = 77.5 F. Absolute Vapor Pressure = 6.5 psia. Thruput = 323,500 bbl.

Rate of loss from 55,000 bbl tank = .00108 of thruput. Total Loss = .00108 x 323,500 = 350 bbl.

LIMITATIONS: 1. The gasoline content of the vapor expelled during filling has been assumed to remain the same as the average static concentration in aluminum painted standard size tanks, half full.

2. Based on average of available test data.

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XUM

# Keeping a step ahead

## of the "Deep Well Pioneers"

## ...NATIONAL TUBE

YEAR AFTER YEAR, deep well drillers probe farther into the unexploited depths of the earth in search of new reservoirs of oil. As each new depth is reached, greater stress is put on the equipment, and fatigue and twisting action are drastically increased.

National Tube, vitally aware of the problems of the oil industry, is constantly striving to anticipate their needs. That is why, during the past twenty-five years, NATIONAL Seamless Drill Pipe, Casing, and Tubing have been continually improved along with the growth and development of the oil industry.

In their search for tubular products of maximum strength, National Tube developed the seamless process, and for the production of seamless pipe, instituted the use of high strength, uniform steel of the very best forging properties. As a result, today's National Seamless Oil Country Tubular products offer extremely high strength, high collapse resistance, and maximum security.

### Here are some recent National Tube Developments of special interest to the oil and gas industry:

**NATIONAL DEOXIDIZED BESSEMER STEEL CASING AND TUBING**

Especially well-suited for oil production because of its combination of high yield strength and good ductility.

**NATIONAL WARM-WORKED CASING**

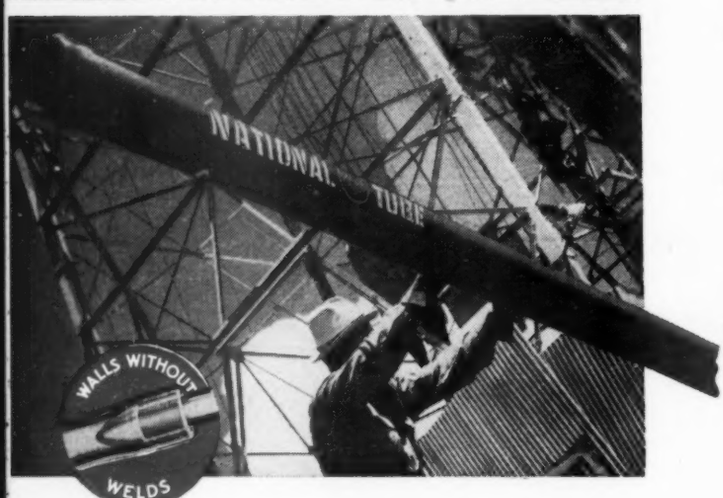
An extremely high-strength casing possessing a uniformity of physical properties which gives it high collapse resistance and greatly increased joint strength.

**NATIONAL DEEP-WELL CASING**

A stronger casing than is provided under A.P.I. specifications, to meet constantly increasing depths. Because it is intended for severe service it is hydrostatically tested to 80% of minimum yield strength up to a maximum of 12,000 p.s.i.

**NATIONAL (B) BUTTRESS-THREAD CASING**

Developed to satisfy the need for a casing joint which will safely and economically support the weight of deep-well casing. The buttress-thread joint is comparable in strength to that of the body of the pipe.



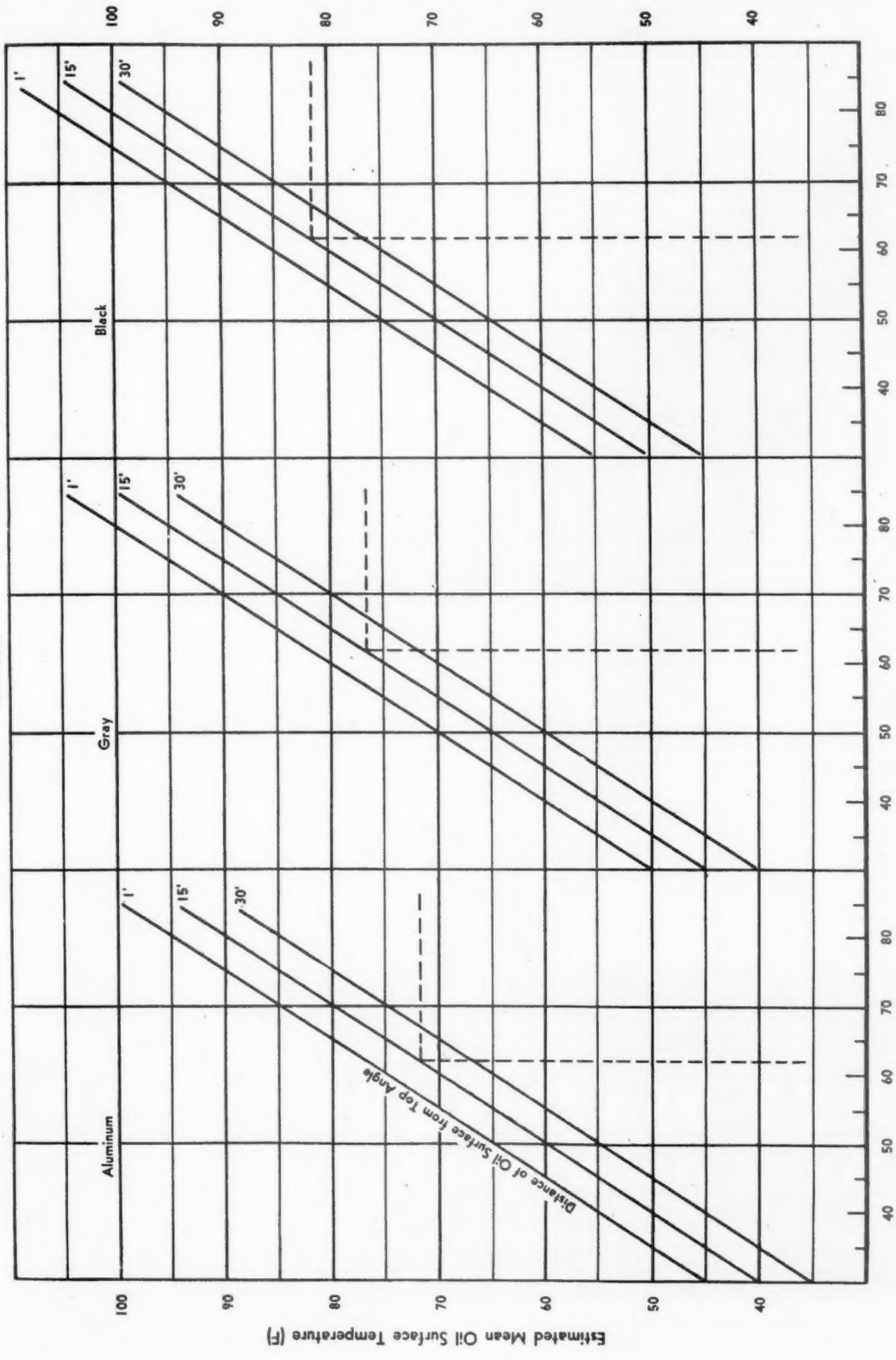

***For further information on National Tube developments in the oil industry, write to National Tube Division, United States Steel Corporation, 525 William Penn Place, Pittsburgh 30, Pa. Ask for Bulletin No. 15.***

NATIONAL TUBE DIVISION, UNITED STATES STEEL CORPORATION
PITTSBURGH, PA.
UNITED STATES STEEL EXPORT COMPANY, NEW YORK

**U·S·S NATIONAL SEAMLESS PIPE AND TUBES**

UNITED STATES STEEL

## ESTIMATED MEAN OIL SURFACE TEMPERATURE—CONE ROOF TANKS WITH CONSERVATION VENTS




EXAMPLE: Product stored in standard size tanks at a mean atmospheric temperature of 62 F has the following liquid surface temperature depending upon the tank color:

Aluminum.....72 F Gray.....77 F Black.....82 F

Source: Socony Vacuum Oil Company Report

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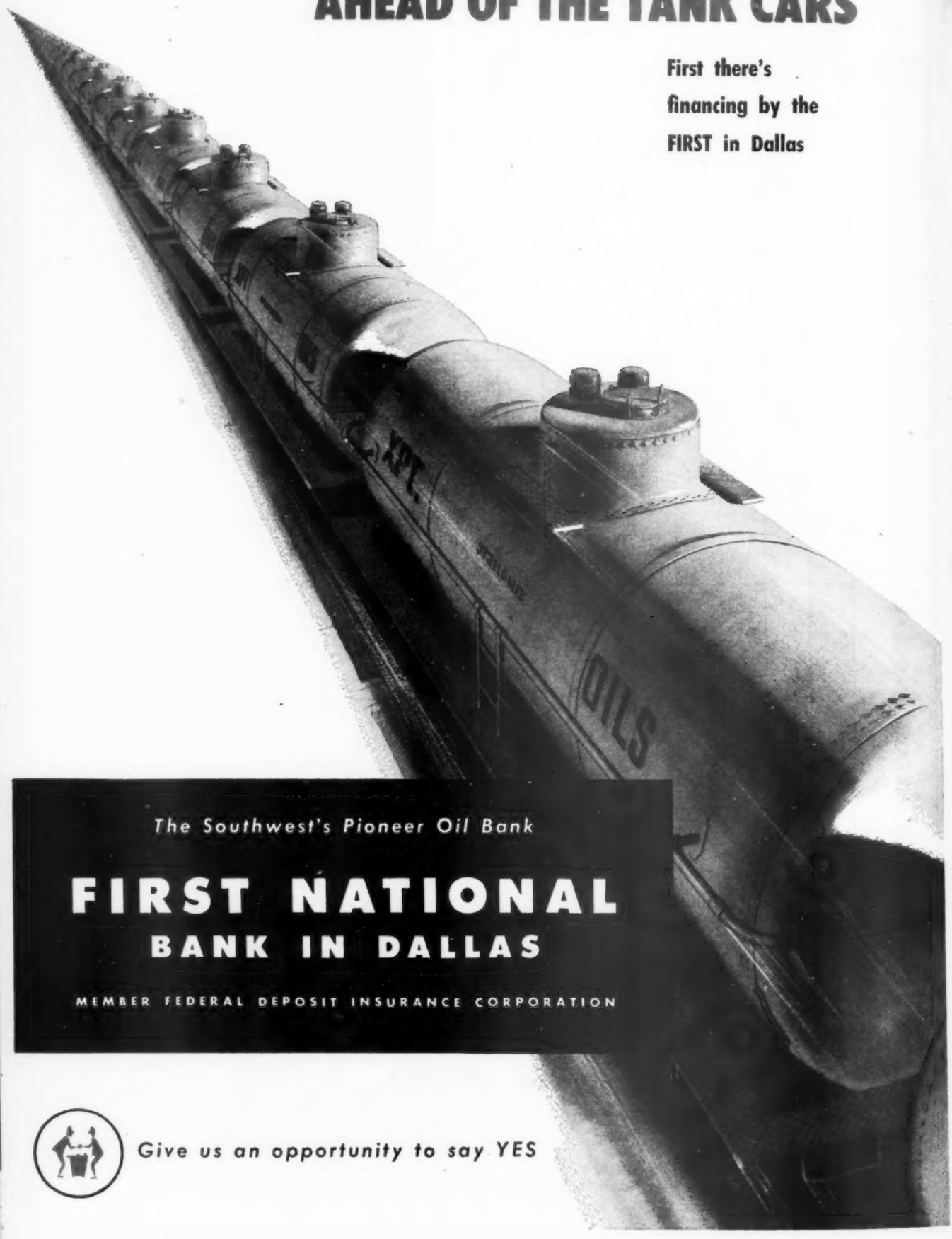
# AHEAD OF THE TANK CARS

**First there's financing by the FIRST in Dallas**




*The Southwest's Pioneer Oil Bank*

## FIRST NATIONAL BANK IN DALLAS

MEMBER FEDERAL DEPOSIT INSURANCE CORPORATION

*Give us an opportunity to say YES*

## ANALYSIS OF WET BULB TEMPERATURES ON A TWENTY-FOUR HOUR BASIS

**Number of Hours in June to September, Inclusive, of a Normal Year, That Wet Bulb Readings Will Equal or Exceed the Temperatures Shown in the Column Headings*†**

| State | City | 81° | 80° | 79° | 78° | 77° | 76° | 75° | 74° | 73° | 72° | 71° |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Alabama | Mobile | 23 | 78 | 182 | 419 | 752 | 1161 | 1612 | 1932 | 2193 | 2321 | 2449 |
| Arizona | Phoenix | | | | 3 | 10 | 44 | 130 | 275 | 472 | 741 | 941 |
| Arkansas | Little Rock | 23 | 59 | 120 | 244 | 397 | 650 | 897 | 1209 | 1502 | 1754 | 1941 |
| California | Fresno | | | | | | | 4 | 12 | 20 | 40 | 88 |
| | Laguna Beach | | | | | | | | | | | |
| | Oakland | | | | | | | | | | | |
| | San Diego | | | | | | | | 9 | 23 | 54 | 109 |
| | Williams | | 4 | 6 | 10 | 14 | 22 | 36 | 55 | 72 | 111 | 160 |
| Colorado | Denver | | | | | | | | | | | |
| | Grand Jctn. | | | | | | | | | | | |
| Connecticut | Hartford | 12 | 20 | 33 | 41 | 55 | 87 | 135 | 185 | 256 | 331 | 430 |
| Dist. of Col. | Washington | 22 | 57 | 90 | 146 | 226 | 359 | 467 | 610 | 785 | 943 | 1162 |
| Florida | Jacksonville | 8 | 56 | 160 | 348 | 686 | 1076 | 1456 | 1818 | 2102 | 2349 | 2518 |
| | Miami | 4 | 12 | 112 | 348 | 836 | 1432 | 1888 | 2214 | 2548 | 2724 | 2800 |
| Georgia | Atlanta | 12 | 29 | 43 | 88 | 163 | 274 | 438 | 671 | 826 | 1195 | 1460 |
| Idaho | Boise | | | | | | | | | | | 3 |
| Illinois | Chicago | | 4 | 17 | 31 | 51 | 85 | 126 | 184 | 252 | 353 | 463 |
| | Moline | 21 | 35 | 52 | 84 | 122 | 183 | 274 | 366 | 474 | 608 | 759 |
| Indiana | Evansville | 24 | 46 | 82 | 150 | 248 | 412 | 608 | 792 | 966 | 1132 | 1322 |
| Kansas | Wichita | | | 3 | 11 | 28 | 55 | 114 | 217 | 364 | 595 | 821 |
| Louisiana | New Orleans | 64 | 205 | 379 | 681 | 1086 | 1462 | 1810 | 2057 | 2301 | 2438 | 2554 |
| | Shreveport | 41 | 94 | 187 | 342 | 540 | 771 | 1077 | 1403 | 1715 | 1936 | 2119 |
| Massachusetts | Boston | | | | 9 | 17 | 29 | 41 | 63 | 97 | 150 | 229 |
| Michigan | Detroit | | | 4 | 6 | 12 | 20 | 36 | 66 | 118 | 218 | 306 |
| Minnesota | St. Paul | | | 4 | 11 | 23 | 46 | 79 | 115 | 162 | 250 | 329 |
| Mississippi | Jackson | 28 | 79 | 189 | 353 | 547 | 825 | 1110 | 1379 | 1647 | 1895 | 2117 |
| Missouri | Kansas City | | | 12 | 26 | 52 | 101 | 217 | 336 | 539 | 745 | 985 |
| | Kirksville | 11 | 23 | 39 | 73 | 115 | 151 | 220 | 326 | 438 | 605 | 772 |
| | St. Louis | | 4 | 13 | 32 | 83 | 169 | 302 | 455 | 624 | 848 | 1016 |
| | Springfield | | | 4 | 14 | 26 | 70 | 166 | 284 | 430 | 658 | 972 |
| Montana | Helena | | | | | | | | | | | |
| Nebraska | North Platte | | | | | | 6 | 10 | 37 | 69 | 133 | 196 |
| | Omaha | | 4 | 11 | 34 | 82 | 163 | 256 | 364 | 480 | 647 | 788 |
| Nevada | Elko | | | | | | | | | | | |
| | Reno | | | | | | | | | | | |
| New Jersey | Camden | 4 | 6 | 18 | 52 | 100 | 154 | 240 | 338 | 428 | 558 | 692 |
| | Newark | 5 | 10 | 14 | 26 | 53 | 92 | 139 | 208 | 292 | 401 | 545 |
| New Mexico | Albuquerque | | | | | | | | | | | |
| New York | Albany | | | | 3 | 4 | 12 | 25 | 65 | 101 | 154 | 219 |
| | Buffalo | | | | | | | 4 | 26 | 88 | 138 | 206 |
| | New York | 3 | 7 | 13 | 33 | 60 | 106 | 143 | 238 | 309 | 406 | 584 |
| N. Carolina | Raleigh | 9 | 19 | 40 | 94 | 180 | 308 | 486 | 707 | 925 | 1192 | 1481 |
| | Wilmington | 4 | 36 | 76 | 240 | 468 | 828 | 1172 | 1504 | 1768 | 1988 | 2172 |
| Ohio | Cincinnati | 5 | 14 | 26 | 64 | 120 | 187 | 282 | 410 | 554 | 722 | 892 |
| | Cleveland | | | 6 | 10 | 21 | 32 | 65 | 107 | 179 | 266 | 373 |
| Oklahoma | Tulsa | | | 13 | 46 | 101 | 205 | 388 | 631 | 843 | 1159 | 1430 |
| Oregon | Portland | | | | | | | | | | | |
| Pennsylvania | Bellefonte | | | | 6 | 13 | 25 | 36 | 60 | 87 | 143 | 224 |
| | Pittsburgh | | | 3 | 6 | 17 | 40 | 60 | 89 | 128 | 195 | 290 |
| S. Carolina | Charleston | 32 | 84 | 182 | 355 | 587 | 833 | 1153 | 1456 | 1756 | 2036 | 2256 |
| S. Dakota | Huron | | | | | | 11 | 24 | 45 | 86 | 134 | 192 |
| | Rapid City | | | | | | | | | | | 8 |
| Tennessee | Knoxville | | | 8 | 31 | 48 | 101 | 202 | 379 | 603 | 850 | 1126 |
| | Memphis | 30 | 66 | 108 | 215 | 326 | 526 | 769 | 1039 | 1318 | 1548 | 1768 |
| Texas | Amarillo | | | | | | | 3 | 3 | 11 | 31 | 86 |
| | Brownsville | | 20 | 111 | 369 | 876 | 1455 | 1904 | 2273 | 2505 | 2623 | 2720 |
| | Dallas | | 5 | 9 | 32 | 133 | 317 | 633 | 1045 | 1438 | 1791 | 2016 |
| | El Paso | | | | | | | | | | 6 | 16 |
| | Houston | 6 | 22 | 123 | 310 | 664 | 1026 | 1493 | 1856 | 2182 | 2383 | 2529 |
| | San Antonio | 23 | 29 | 43 | 84 | 142 | 323 | 684 | 1177 | 1606 | 1998 | 2285 |
| Utah | Modena | | | | | | | | | | | |
| | Salt Lake City | | | | | | | | | | | |
| Washington | Seattle | | | | | | | | | | | |
| | Spokane | | | | | | | | | | | |
| Wisconsin | Green Bay | | | 9 | 16 | 21 | 38 | 59 | 100 | 147 | 207 | 266 |
| | La Crosse | 18 | 38 | 59 | 80 | 115 | 148 | 199 | 268 | 340 | 444 | 524 |
| Wyoming | Rock Springs | | | | | | | | | | | |

*All readings of 2 hours or less have been omitted.
†Temperatures are in degrees Fahrenheit.

*Courtesy of Marley Company*

they pick it ON PERFORMANCE

Cutler-Hammer

# "Oil Country" Control

Steadily the preference for Cutler-Hammer Oil Well Pumping Control grows. Its performance *proves* it is the genuine Oil Country Control . . . built to oil men's practical specifications not only to start, stop and protect motors and equipment . . . but built to stop the oil country enemies of performance in their tracks.

Aluminum coated cases bounce back the sun's heat. Chimney-draft type ventilation sucks off heat, sucks in cooler air. (You never see a C-H Control cover door propped open to keep it running.) "Out in the open" contacts stay cooler, and, being vertical, shed dust. Ventilator openings are screened, louvred and baffled to keep out dust and dirt and bugs. Neoprene gasketing shields the timer. Excess clock motor torque keeps it ticking along.

Optional 3-coil overload protection ends single phasing; standard 2 coil suffices where single phasing is not a problem.

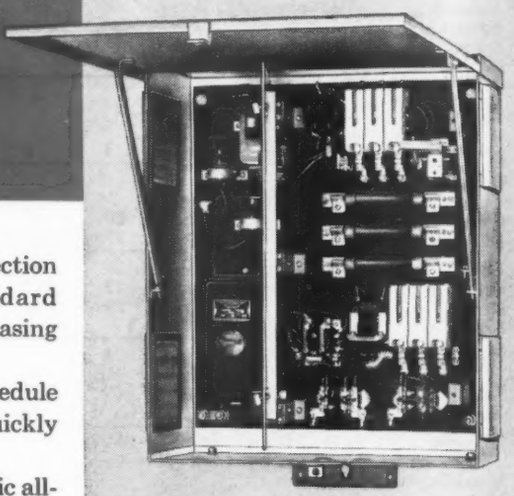
Any type of pumping schedule plus day omission is easily, quickly available.

There's manual or automatic all-at-once or time delay staggered starting available.

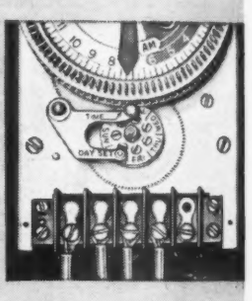
Lightning arrestors protect but don't blow up the works when they pop.

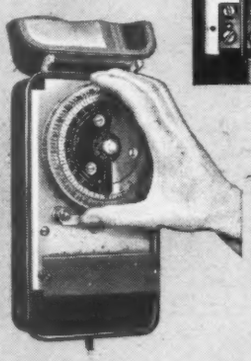
There's every reason in the world for this control's increasing popularity . . . *every reason in the world for you to investigate it too. You'll be glad you did.* CUTLER-HAMMER, Inc., 1459 St. Paul Avenue, Milwaukee 1, Wisconsin. *Associate:* Canadian Cutler-Hammer, Ltd., Toronto, Ontario.

Cutler-Hammer 9589 Oil Well Pumping Controller with 3 coil overload protection and time delay relay.

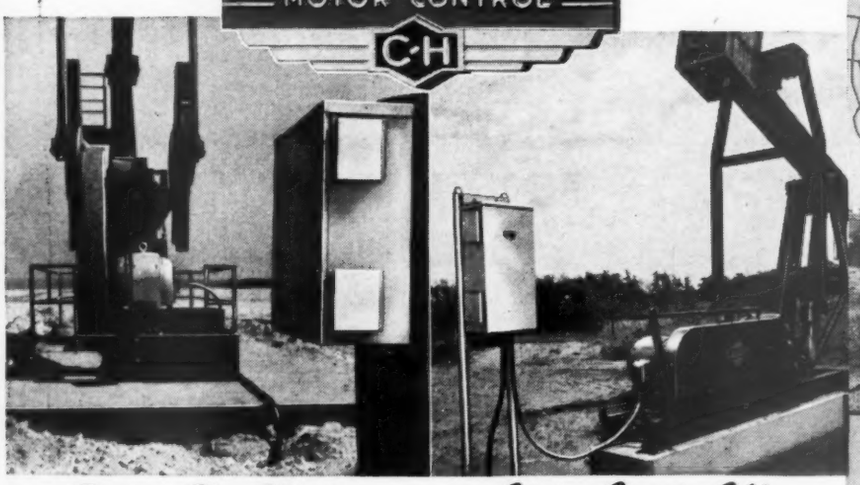


Day-omission feature—for non-operation any selected days of week.





Cutler-Hammer Program Time Switch gives automatically scheduled pumping, set up easily by means of pull tabs—one for each 15-minute interval.




*Eunice, New Mexico* *Carter County, Okla.*

*Scurry County, Texas*

MEMBER AMERICAN PETROLEUM INSTITUTE

## ANALYSIS OF WET BULB TEMPERATURES ON A TWENTY-FOUR HOUR BASIS

**Number of Hours in June to September, Inclusive, of a Normal Year, That Wet Bulb Readings Will Equal or Exceed the Temperatures Shown in the Column Headings*†**

| 70° | 68° | 66° | 64° | 62° | 60° | 55° | 50° | 40° | 30° | 20° | Avg. | Des. | City |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2562 | 2660 | 2732 | 2803 | 2843 | 2878 | 2921 | 2928 | 2928 | 2928 | 2928 | 73.8 | 79.3 | Mobile |
| 1191 | 1559 | 1847 | 2108 | 2322 | 2490 | 2730 | 2876 | 2928 | 2928 | 2928 | 66.5 | 74.9 | Phoenix |
| 2118 | 2375 | 2524 | 2631 | 2710 | 2762 | 2881 | 2925 | 2928 | 2928 | 2928 | 71.3 | 78.8 | Little Rock |
| 140 | 346 | 642 | 1018 | 1422 | 1812 | 2570 | 2872 | 2928 | 2928 | 2928 | 61.1 | 69.9 | Fresno |
| 16 | 64 | 238 | 664 | 1282 | 1874 | 2828 | 2926 | 2928 | 2928 | 2928 | 60.8 | 66.6 | Laguna Bch. |
| | 4 | 24 | 71 | 207 | 473 | 1966 | 2829 | 2928 | 2928 | 2928 | 56.1 | 62.7 | Oakland |
| 206 | 506 | 884 | 1310 | 1813 | 2319 | 2881 | 2926 | 2928 | 2928 | 2928 | 63.1 | 70.5 | San Diego |
| 211 | 402 | 681 | 972 | 1290 | 1601 | 2267 | 2700 | 2926 | 2928 | 2928 | 60.0 | 71.2 | Williams |
| | 9 | 32 | 117 | 366 | 732 | 1813 | 2508 | 2877 | 2927 | 2928 | 55.4 | 63.6 | Denver |
| | 4 | 48 | 200 | 522 | 944 | 1844 | 2452 | 2906 | 2928 | 2928 | 58.9 | 64.5 | Grand Jctn. |
| 545 | 858 | 1148 | 1513 | 1824 | 2090 | 2557 | 2804 | 2923 | 2928 | 2928 | 63.2 | 74.6 | Hartford |
| 1355 | 1727 | 2043 | 2314 | 2506 | 2641 | 2843 | 2910 | 2928 | 2928 | 2928 | 68.2 | 78.0 | Washington |
| 2633 | 2776 | 2837 | 2866 | 2893 | 2911 | 2927 | 2928 | 2928 | 2928 | 2928 | 73.9 | 79.1 | Jacksonville |
| 2850 | 2886 | 2914 | 2918 | 2926 | 2928 | 2928 | 2928 | 2928 | 2928 | 2928 | 75.0 | 78.8 | Miami |
| 1747 | 2120 | 2396 | 2560 | 2655 | 2728 | 2862 | 2922 | 2928 | 2928 | 2928 | 69.6 | 77.2 | Atlanta |
| 11 | 30 | 96 | 216 | 452 | 743 | 1515 | 2221 | 2875 | 2925 | 2928 | 54.4 | 65.1 | Boise |
| 605 | 861 | 1158 | 1451 | 1740 | 2010 | 2519 | 2768 | 2922 | 2928 | 2928 | 62.8 | 74.6 | Chicago |
| 894 | 1166 | 1450 | 1733 | 1984 | 2197 | 2586 | 2806 | 2917 | 2928 | 2928 | 64.6 | 76.5 | Moline |
| 1512 | 1818 | 2060 | 2296 | 2456 | 2594 | 2814 | 2902 | 2928 | 2928 | 2928 | 68.6 | 78.0 | Evansville |
| 1065 | 1492 | 1863 | 2106 | 2302 | 2437 | 2679 | 2846 | 2928 | 2928 | 2928 | 66.0 | 74.6 | Wichita |
| 2639 | 2755 | 2817 | 2855 | 2889 | 2907 | 2927 | 2927 | 2928 | 2928 | 2928 | 74.7 | 80.1 | New Orleans |
| 2291 | 2484 | 2615 | 2715 | 2776 | 2827 | 2910 | 2928 | 2928 | 2928 | 2928 | 72.3 | 79.4 | Shreveport |
| 324 | 570 | 870 | 1213 | 1588 | 1989 | 2609 | 2843 | 2928 | 2928 | 2928 | 62.1 | 72.0 | Boston |
| 452 | 736 | 1038 | 1362 | 1656 | 1964 | 2530 | 2804 | 2928 | 2928 | 2928 | 62.3 | 72.6 | Detroit |
| 416 | 648 | 914 | 1179 | 1478 | 1761 | 2294 | 2659 | 2901 | 2928 | 2928 | 60.9 | 73.3 | St. Paul |
| 2290 | 2496 | 2619 | 2712 | 2783 | 2828 | 2889 | 2921 | 2928 | 2928 | 2928 | 72.2 | 79.4 | Jackson |
| 1227 | 1620 | 1910 | 2166 | 2384 | 2529 | 2770 | 2883 | 2927 | 2928 | 2928 | 66.9 | 75.5 | Kansas City |
| 985 | 1325 | 1597 | 1840 | 2055 | 2269 | 2597 | 2808 | 2920 | 2928 | 2928 | 65.1 | 76.1 | Kirksville |
| 1215 | 1534 | 1832 | 2082 | 2294 | 2479 | 2765 | 2876 | 2928 | 2928 | 2928 | 66.8 | 76.2 | St. Louis |
| 1292 | 1750 | 2060 | 2334 | 2496 | 2630 | 2822 | 2900 | 2928 | 2928 | 2928 | 67.4 | 75.2 | Springfield |
| 4 | 8 | 12 | 64 | 140 | 344 | 1100 | 1972 | 2812 | 2924 | 2928 | 52.0 | 61.9 | Helena |
| 296 | 565 | 899 | 1215 | 1585 | 1904 | 2420 | 2684 | 2880 | 2923 | 2928 | 61.0 | 71.6 | North Platte |
| 988 | 1327 | 1654 | 1924 | 2141 | 2343 | 2648 | 2810 | 2915 | 2928 | 2928 | 65.4 | 76.2 | Omaha |
| | | | 6 | 56 | 170 | 810 | 1440 | 2348 | 2852 | 2920 | 47.8 | 60.3 | Elko |
| | | 10 | 68 | 156 | 342 | 1042 | 1780 | 2674 | 2916 | 2928 | 50.8 | 62.1 | Reno |
| 850 | 1158 | 1460 | 1786 | 2134 | 2376 | 2748 | 2872 | 2928 | 2928 | 2928 | 65.3 | 76.2 | Camden |
| 722 | 1092 | 1440 | 1756 | 2082 | 2330 | 2726 | 2886 | 2928 | 2928 | 2928 | 64.8 | 74.8 | Newark |
| | 9 | 140 | 486 | 1001 | 1530 | 2370 | 2716 | 2918 | 2928 | 2928 | 58.7 | 65.7 | Albuquerque |
| 302 | 510 | 739 | 998 | 1287 | 1628 | 2299 | 2687 | 2910 | 2928 | 2928 | 60.2 | 72.2 | Albany |
| 314 | 506 | 700 | 982 | 1248 | 1526 | 2140 | 2616 | 2902 | 2928 | 2928 | 59.5 | 71.7 | Buffalo |
| 765 | 1123 | 1464 | 1832 | 2126 | 2367 | 2760 | 2896 | 2928 | 2928 | 2928 | 65.0 | 75.0 | New York |
| 1686 | 2055 | 2313 | 2485 | 2616 | 2705 | 2853 | 2909 | 2928 | 2928 | 2928 | 69.3 | 77.3 | Raleigh |
| 2312 | 2452 | 2580 | 2648 | 2704 | 2756 | 2880 | 2924 | 2928 | 2928 | 2928 | 72.0 | 78.3 | Wilmington |
| 1100 | 1441 | 1742 | 2024 | 2248 | 2436 | 2733 | 2859 | 2928 | 2928 | 2928 | 66.3 | 76.6 | Cincinnati |
| 468 | 770 | 1080 | 1443 | 1760 | 2076 | 2528 | 2800 | 2924 | 2928 | 2928 | 62.7 | 73.4 | Cleveland |
| 1699 | 2095 | 2357 | 2539 | 2640 | 2712 | 2849 | 2912 | 2928 | 2928 | 2928 | 69.2 | 76.5 | Tulsa |
| 10 | 54 | 162 | 318 | 558 | 885 | 2037 | 2767 | 2928 | 2928 | 2928 | 57.0 | 66.1 | Portland |
| 315 | 571 | 892 | 1202 | 1512 | 1824 | 2421 | 2744 | 2915 | 2928 | 2928 | 61.2 | 71.9 | Bellefonte |
| 427 | 748 | 1059 | 1470 | 1796 | 2070 | 2622 | 2830 | 2928 | 2928 | 2928 | 62.8 | 72.6 | Pittsburgh |
| 2404 | 2603 | 2708 | 2780 | 2823 | 2859 | 2906 | 2925 | 2928 | 2928 | 2928 | 72.8 | 79.3 | Charleston |
| 291 | 502 | 776 | 1066 | 1401 | 1688 | 2253 | 2871 | 2926 | 2928 | 2928 | 59.9 | 71.6 | Huron |
| 19 | 107 | 240 | 464 | 818 | 1102 | 1900 | 2419 | 2860 | 2918 | 2928 | 56.4 | 67.3 | Rapid City |
| 1411 | 1907 | 2201 | 2456 | 2608 | 2729 | 2851 | 2917 | 2928 | 2928 | 2928 | 68.3 | 75.4 | Knoxville |
| 1947 | 2216 | 2401 | 2544 | 2656 | 2736 | 2879 | 2916 | 2928 | 2928 | 2928 | 70.6 | 78.6 | Memphis |
| 187 | 561 | 1050 | 1571 | 2022 | 2356 | 2750 | 2866 | 2919 | 2928 | 2928 | 63.2 | 70.4 | Amarillo |
| 2795 | 2877 | 2912 | 2922 | 2928 | 2928 | 2928 | 2928 | 2928 | 2928 | 2928 | 75.0 | 78.8 | Brownsville |
| 2208 | 2468 | 2615 | 2709 | 2769 | 2807 | 2896 | 2927 | 2928 | 2928 | 2928 | 71.2 | 76.9 | Dallas |
| 48 | 272 | 809 | 1444 | 1942 | 2316 | 2719 | 2885 | 2928 | 2928 | 2928 | 62.5 | 68.6 | El Paso |
| 2637 | 2749 | 2824 | 2858 | 2884 | 2902 | 2927 | 2928 | 2928 | 2928 | 2928 | 73.9 | 78.8 | Houston |
| 2466 | 2651 | 2767 | 2825 | 2868 | 2897 | 2926 | 2928 | 2928 | 2928 | 2928 | 72.2 | 76.7 | San Antonio |
| | | 8 | 39 | 209 | 452 | 1225 | 1868 | 2597 | 2910 | 2928 | 51.2 | 62.5 | Modena |
| 4 | 6 | 36 | 104 | 246 | 484 | 1644 | 2506 | 2916 | 2928 | 2928 | 54.9 | 63.2 | Salt Lake City |
| | 16 | 92 | 268 | 508 | 828 | 1663 | 2302 | 2832 | 2928 | 2928 | 54.8 | 65.2 | Seattle |
| | 4 | 15 | 66 | 152 | 326 | 1082 | 2048 | 2842 | 2923 | 2928 | 52.3 | 62.1 | Spokane |
| 341 | 539 | 769 | 1048 | 1326 | 1619 | 2287 | 2668 | 2908 | 2928 | 2928 | 60.2 | 73.0 | Green Bay |
| 613 | 853 | 1123 | 1385 | 1638 | 1880 | 2407 | 2712 | 2902 | 2928 | 2928 | 62.4 | 76.1 | La Crosse |
| | | | | 10 | 70 | 718 | 1554 | 2558 | 2896 | 2928 | 48.8 | 59.1 | Rock Springs |

*All readings of 2 hours or less have been omitted.
†Temperatures are in degrees Fahrenheit.

*Courtesy of Marley Company*

# LAUGH with BARNEY

Sign in restaurant at Sulphur Springs, Texas:

OYSTERS
Stewed
Fried
Nude

Six-year-old Jerry came downstairs bellowing lustily. "What's the matter?" asked his mother.

Papa was hanging pictures and he just hit his thumb with a hammer," Said Jerry.

'That's not so serious," soothed his mother. "A big man like you shouldn't cry at a trifle like that. Why don't you just laugh?"

"I did," sobbed Jerry.

Two drillers sat down to eat their lunch. One began to unwrap a package some 18 inches long.

"What's that?" asked the other.

"My wife's away," said the first, "so I made myself a pie."

"A bit long, ain't it?" his friend asked.

"Long? Sure, it's long. It's rhubarb."

Three men walked into the railroad station and, after checking schedules, decided they had time for a few drinks. Finally they leaped up and ran, just in time for two of them to catch the train. The third fell down and began to laugh.

"What are you laughing about?" asked a witness.

"Those two guys," said the merrymaker, "came down here to see me off!"

Mother (to finicky child at table): "Eat it, dear — pretend it's mud "

He was applying for county relief and the young lady was filling in the usual form.

Clerk: "Do you owe any back house rent?"

He: "We ain't had a back house for years. We got inside plumbing.

A hotel manager received this wire: "Have you suitable accommodations where I can put up with my wife?"

Very late one night two chaps who had been imbibing too freely were sitting on the pavement with their feet in the gutter. One was heard to say to the other, "What does your wife shay when you shtay out late like thish?"

"Haven't got a wife," the other replied.

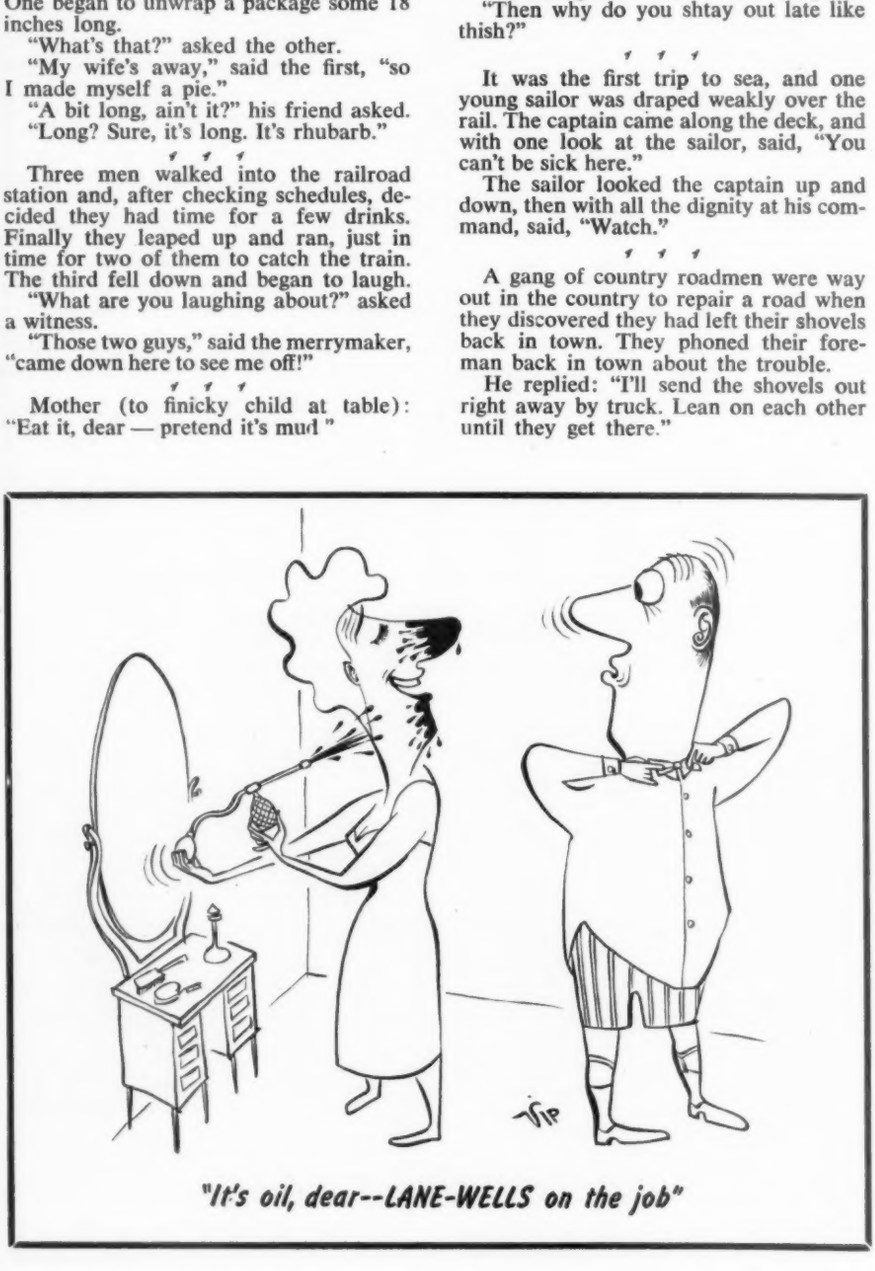
"Then why do you shtay out late like thish?"

It was the first trip to sea, and one young sailor was draped weakly over the rail. The captain came along the deck, and with one look at the sailor, said, "You can't be sick here."

The sailor looked the captain up and down, then with all the dignity at his command, said, "Watch."

A gang of country roadmen were way out in the country to repair a road when they discovered they had left their shovels back in town. They phoned their foreman back in town about the trouble.

He replied: "I'll send the shovels out right away by truck. Lean on each other until they get there."



*"It's oil, dear--LANE-WELLS on the job"*

"Yes, this is a nice little apartment, but I don't seen any bath."

"Oh, pardon me! I thought you were one of those college boys who want a place just for the winter."

As the young lady oyster snuggled back into the sea after her first date with the dashing lobster, she nudged her girl friend and whispered: "It was wonderful. Simply wonderful. He took me to that secluded rock near the sandbar, looked into my eyes, whispered sweet nothings in my ear put his arms around me, and then . . ."

As she uttered these last words the lady oyster clutched her throat and groaned in mortification. "Oh, Good Lord — my pearls!"

An airline passenger rushed into the ticket office in San Francisco the other day, clutching his ticket in one hand and his hat in the other:

"Has the limousine for the flight to New York left yet?" he hollered, all out of breath and wringing wet.

The ticket girl took her time about looking up, and replied in her most soothing tone, "No sir, it's just outside the door. Hop in."

The man rushed off. All was serene for a couple of hours. Then who should appear at the counter again but the same passenger, no longer panting, and with a look of resignation written all over his face. "I have just had a two-hour tour of Chinatown," he announced. "What do I do now?"

After the three men had been assigned a room on the 30th floor, they went out to dinner. They were shocked to find, upon their return to the hotel, people sleeping in the lobby. The elevators were out, the clerk said.

To occupy their minds during the long climb they devised a plan whereby the first man would tell funny stories the first 10 flights; the second man would tell adventure tales the second 10 flights, and the third man would relate sad experiences the last 10.

With their laughter, the first 10 flights were easy. And the adventure yarns kept the second 10 from being unpleasant. At the 21st floor the third man was silent, and he didn't say anything at the 22nd floor either.

"Let's have those sad stories," he was urged.

"All right, I'll tell the saddest of all first," he said. "I forgot the key."

When the revenuers burst from the bushes, the gangling hillbilly moonshiner lit out at such speed that the men could only stand in slack-jawed awe and watch him disappear.

Long after the revenue men had left, the hillbilly still had not returned to his cabin. Hours became days, and his friends began worrying about him.

At last, on the fifth day, he stumbled in, a sorry sight. He was bearded and fatigued, his clothes were spattered with mud.

"Where you been, Ed?" one of his friends asked.

He sighed wearily. "I been comin' back."

*Edna:* "You mustn't get discouraged. In this world there's a man for every girl and a girl for every man. You can't improve on an arrangement like that."

*Pearl:* "I don't want to improve on it. I just want to get in on it."

# OIL and GAS TRADE NEWS

**Al Capp (right) creator of one of America's most popular comic strips, "Li'l Abner," is shown here with executives of Johnston Testers, Inc., for whom he is doing a series of cartoon advertisements. Series features "Available" and "Accurate" Johnston, created especially for Johnston Testers by Capp. With Capp are J. E. Smith, vice president in charge of sales, and Tom Johnston, executive vice president.**

### Clark Opens New Office

Opening of a new sales office at Shreveport, Louisiana, has been announced by Clark Bros. Company. The new office is at 930 Texas Eastern Building, Shreveport, Louisiana. James R. Hutton has been named sales engineer for the new office. Hutton, a Texas University graduate, was transferred from the Clark Houston office.

### New Plant Planned For Brazil Subsidiary

To provide modern earthmoving equipment for Brazil's expanding economy, LeTourneau-Westinghouse Company, a subsidiary of Westinghouse Air Brake Company, will build a new plant in Brazil, it was announced by Edward O. Boshell, chairman and president of Westinghouse Air Brake. The new plant, which will be about 60 miles from Sao Paulo near the industrial city of Campinas, will be the property of Tratores do Brasil S. A., newly established operating subsidiary of LeTourneau-Westinghouse.

Afranio A. Ferreira, the LeTourneau-Westinghouse representative in Brazil, will be president of the new company.

### New Agents Are Named

The Buda Company, division of Allis-Chalmers Manufacturing Company, has announced that its subsidiary, Buda Engine and Equipment Company, Inc., succeeds its former distributor, Buda Engine Sales and Service, Inc., in the states of Oklahoma and Kansas. The factory branch will be at the same address, 521 West Archer Street, in Tulsa, Oklahoma.

### Plico Moves Headquarters

Announcement has been made of acquisition of larger quarters by Pipeline Coating and Engineering Company, Inc. Formerly at 2850 East Florence Avenue in Huntington Park, the company has moved its factory and offices to 1566 East Slauson Avenue, Los Angeles 11, California.

### Lufkin Production Men

A large group of sales, service, and production representatives attended the annual sales meeting of Lufkin Foundry and Machine Company held in Lufkin, Texas, recently.

Some 65 representative from major cities throughout the United States, and from Canada and South America attended the four-day conclave. L. A. Little, vice president in charge of sales, presided at the sessions.

### Waukesha Holds Annual General Sales Meeting

Fifty-five representatives of Waukesha Sales and Service, Inc. attended the company's annual general sales meeting which was held January 18-22 at the Ben Milam Hotel, Houston, Texas. Louis M. Pearce, Jr., president of Waukesha Sales and Service, Inc., conducted the meetings. Included on the program were officers and executives from various manufacturing companies who are represented by Waukesha Sales and Service, Inc.

### Butler Salesmen Meet

At their first general sales meeting in five years Butler Manufacturing Company officials at Kansas City announced to their oil equipment salesmen that the oil industry is off to a good start in 1954 and by the year's end should have tabbed a four per cent increase over last year.

Highlighting the three-day conference was a two-hour-long "Butler Product Revue" in the huge arena of Kansas City's Municipal Auditorium.

**James D. Hughes, general sales manager, Lane-Wells Company, and Rodney S. Durkee, president discussed sales plans for 1954 at the company's recent convention in Galveston, Texas. Hughes directed classes held in perforating, logging, and merchandising sales, and new products were demonstrated by engineers and representatives. At right is, champion oil equipment salesman for Butler Manufacturing, Frank G. Royster, who was presented a silver loving cup designating him as honorary vice president of the exclusive "Butler Cup Club," for being the top salesman in Butler's oil equipment division. With Royster are Oscar Nelson, president; Harold Edlund, general sales manager; Glenn Speakman, vice president in charge of sales, and John Morgan, general manager.**



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*you can RELY ON-*

**GORMAN-RUPP**

**SELF-PRIMING CENTRIFUGAL PUMPS**

10 M, 2 IN. PUMP

PELICAN 2 IN. PUMP

4 IN. ELECT. MOTOR DRIVEN PUMP

**FOR MORE TROUBLE-FREE USE WITH LESS FUEL AND LESS MAINTENANCE**

These pumps are built for hard use. Three months continuous runs without shutdowns are not uncommon.

Gorman-Rupp Pumps are the Quickest Priming, Highest Priming, Fastest Pumping and Most Reliable pumps available.

A COMPLETE LINE OF CENTRIFUGAL PUMPS IS AVAILABLE FROM ¾", 1000 G.P.H. UP TO 10", 240,000 G.P.H. CAPACITY.

Mid-Continent and Gulf Coast Oilfield Representative

**HENRY H. PARIS DISTRIBUTOR, INC.**

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**THE GORMAN-RUPP COMPANY**

MANSFIELD, OHIO



**NOW! SHAFT DRIVE POWER in LIGHT hauling!**

TOTAL OPERATING COST ¾¢ PER MILE

- **EXTRA** POWER
- **EXTRA** CAPACITY
- **EXTRA** ECONOMY

Slash inner plant handling and delivery costs as have hundreds of other plants. Put Cushman 780 TRUCKSTERS on your jobs—NEW this year with SHAFT DRIVE. Complete with 3 speeds forward, one reverse. Get the EXTRA power advantages of big vehicle shaft drive—plus quick, easy handling AND low operating cost—less than a penny a mile. With capacity up to 500 pounds, TRUCKSTER can speed up hundreds of handling jobs for you!

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780 SHAFT DRIVE TRUCKSTER

- Write for FREE illustrated booklet
- See Your Nearest Cushman Dealer for FREE demonstration

SOLD and SERVICED NATIONALLY

**CUSHMAN MOTOR WORKS, INC.**

969 No. 21st St.
Lincoln, Nebraska


## Trade News

### Four New Centers Opened By Schlumberger Well

Four new operating centers to bring Schlumberger service closer to centers of increased drilling activity have been opened by Schlumberger Well Surveying Corporation, Houston.

Three of the new offices are in South Louisiana at Donaldsonville, Morgan City, and Golden Meadow. Operations began at Donaldsonville and Morgan City in October and at Golden Meadow and Refugio, the fourth new center, in November. The Donaldsonville center is under supervision of J. T. Douglas, Morgan City under William H. Player, and Golden Meadow under Ben Ryland. F. A. Rice is in charge of the Refugio, Texas location.

### Telematic Stock Purchased

O. W. Graham, president of Instruments, Inc., announces purchase of all patents, dies, fixtures, materials, and trade marks of the Telematic Corporation., Chicago, Illinois. Manufacture, sales and service of the gage will be handled by Instruments, Inc., or their sales representatives.

### Cummins Presents Awards

Service awards were presented Fort Worth Cummins Sales and Service, Inc., employees in recent ceremonies.

The awards, gold and diamond replicas of the company's trademark emblem, were conferred by Ken W. Davis, president and vice president—sales, J. T. Calnon.

J. L. Peeler received a 15-year award. Ten-year awards were conferred upon L. J. Troutz and J. A. Webb. Five-year service awards went to Nona Armstrong, G. E. Ball, C. E. Bullington, H. B. Burr, J. T. Calnon, L. C. Gilstrap, L. C. Hardin, J. P. Hunter, A. R. Kennedy, H. L. McIntosh, D. M. Peacock, A. J. Poplin, K. E. Rich, and Roosevelt Williams.

### Service Pins Awarded

Twenty-six employees of Continental Supply Company were honored recently at a service pin award dinner in Houston, Texas. Pins for 15 years and five years service were presented.

F. I. Brinegar, executive vice president, Dallas, Texas, presented the pins. Those receiving pins were: For 15 years: S. Q. Bates, D. F. Bell, D. P. Davis, E. E. Files, R. A. Gentry, R. F. Gregg, Raleigh Hortenstine, Jr., Tony Kovach, L. D. McNeill, Jake Voigt and E. E. Tyer, all Houston; C. G. Cuthbertson and G. R. Runnels, Corpus Christi; G. W. Patterson, Alice, Texas; John Silhavy, New Iberia, Louisiana; and W. E. Young, San Antonio, Texas.

For 5 years: G. P. Daley, E. V. Frames, P. W. Parker and Mrs. Jessica Tomlinson, all Houston; L. D. Boyne, Houma, Louisiana; G. V. Cole, El Campo, Texas; C. B. Herring and B. V. Mills, Corpus Christi; M. S. Holleman, New Iberia; and R. J. Rosteet, Lake Charles, Louisiana.

### Trane Company Moves To New Location

The Trane Company announces the new location of two sales offices. The Greenville, South Carolina, sales office is now located at 214 McDaniel Avenue. R. G. Beck is sales engineer in charge of the office. The Duluth, Minnesota, sales office is now at 2830 West Superior. Robert T. Dean is sales engineer in charge of the office.

**On pipeline trenches,** slush pits, footings, firewalls and other below-grade excavations, this Koehring heavy-duty ½-yard hoe reaches a long way down . . . digs 17 feet-9 inches below tracks. Husky, 32-inch-wide dipper comes up with a full load every pass, in any kind of dirt or rock. That's because the dipper cutting angle is easily changed to best suit digging conditions and type of cut being made. 3 settings are provided on the dipper arm.

**No side-sway . . .** In hardest digging, dipper won't turn away from the cut. Wide boom-point provides a rigid connection to the dipper arm. Makes a straight, clean cut every time. Close-coupled dipper pulls up tight to the boom, avoids spillage as boom raises out of the cut. Long reach lets hoe dump far beyond edge of trench, or gives 10-foot clearance height to load trucks.

**Full operating efficiency** is maintained at all times because Koehring 205 main clutches are self-adjusting. Heat-compensator springs make tension changes automatically. No time out for continuous manual settings . . . saves time, pays off in improved control and extra production with every Koehring 205 attachment.

**Interchangeable** shovel, dragline, clamshell, and crane increase the 205's all-purpose usefulness. It has 10-ton lift capacity on crawlers . . . 15-ton capacity as a truck crane. See Koehring distributor.

K372REV

**KOEHRING Company** MILWAUKEE 16, WIS.
(Subsidiaries: PARSONS • KWIK-MIX • JOHNSON)

EXCAVATORS ½ to 2½ yards . . . CRANES up to 79½ tons lift capacities

JET-LUBE
21 THREAD LUBRICANT

EASY "BREAK-OUT"

Exceptional non-galling and easy "break out" of drill pipe. Low friction moly-disulphide in high temperature silica grease! Use it on those extra tough jobs. JET-LUBE 21 does a remarkable job at low cost. Batch controlled. Fully guaranteed.

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FORCE FEED LUBRICATORS

For operation against discharge pressures of up to 30,000 P.S.I.G.

CHEMICAL FEEDERS

Capacities from .6 pint to 17.5 gallons per hour.

. . . ENGINEERED TO YOUR INDIVIDUAL NEEDS

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DIVISION OF FRONTIER INDUSTRIES, INC.
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A. A. Turner

J. S. Zink

R. D. Reed

W. A. Freiwald

A. C. Sweeney, Jr.

E. H. Hurst

E. C. Huge

## Zink Heating Seminar Set

The Fourth Process Heating Seminar, under the auspices of the John Zink Company will be held at the John Zink plant, 4401 South Peoria Street, Tulsa, Oklahoma, on Saturday, April 17, at 1:00 p.m. according to a recent announcement by that company. Registration will begin at 11:00 a.m. Saturday.

The papers to be presented include:

"Application of Additives to the Burning of Residual Fuel Oils," by E. C. Huge, Research Division, Babcock & Wilcox Co.

"Refractories from Man-Made Minerals for Process Equipment," by A. A. Turner and Roy W. Brown, Carborundum Co.

"Ion Exchange Treatment of Process Water," by E. H. Hurst & W. A. Freiwald, National Aluminate Corp.

"Radioisotope Radiography and X-Ray Diffraction Analysis as Applied to Refinery Problems," by Arthur C. Sweeny, Jr.

Invitations and confirmation cards, for intention to attend the Seminar may be obtained either from John Zink Company, Box 7216, Brookside, Tulsa 18, Oklahoma, or from company representatives in New York, Los Angeles, Houston, Detroit, Pittsburgh, Salt Lake City, Chicago and St. Louis. Those expecting to attend are urged to send in confirmation cards so that arrangements may be made for the buffet dinner which is to follow the meeting.

## New Divisions Formed

Pacific Coast Borax Company, division of Borax Consolidated, Ltd., has announced establishment of a new railroad department in its agricultural sales division to be headed by G. C. Buskirk, who has been with the company since 1948.

The company also announces appointment of R. S. Kiester to be the manager of its agricultural sales division's new district office at Houston, Texas. He joined the Pacific Borax Company in 1950 as its Houston representative.

Pacific Coast Borax also announced establishment of a new plant food division to be headed by Dr. James A. Naftel. Dr. Naftel will be responsible for the direction of sales and sales development in this division of Borax Consolidated.

## France Story Told

The France Packing Company has published a 32-page booklet announcing its recent move to 9925 Bustleton Avenue, Philadelphia, Pennsylvania. The booklet is cleverly illustrated with cartoons depicting olden days. The company was organized in 1898 by A. W. France. In the late 1920's the son of the founder, E. A. France, organized the France Manufacturing Company to develop and manufacture packing and related parts used in gas compressors that would withstand higher speeds, pressures, temperatures, and chemical reactions. The two companies were merged in 1949.

## Axelson Sales High

Pressed Steel Car Company, Inc., announced that acquisition of Axelson Manufacturing Company was probably the company's most profitable diversification move to date. Walter F. Wilmas, executive vice president of Pressed Steel Car said Axelson was acquired in 1952 as a part of Pressed Steel Car's diversification program. In 1952 Axelson's sales jumped to $20,000,000 from $11,000,000 the year before, and last year sales hit almost $25,000,000 according to Wilmas. New long and short stroke oil pumps are expected to make sales go higher than ever this year, Wilmas added.

## Vinson Begins Operations In New Warehouse Plant

The largest plant of its type in Texas, Vinson Supply Company's new $1,500,000 steel warehouse in Dallas is now complete, G. B. Lane, executive vice president of the company, announced. The plant, an all-steel structure, provides 110,000 sq ft of warehousing floor space with an additional 11,000 sq ft of office space still under construction. One feature of the new plant is the first 48-in. coil slitting line in the Southwest. The line reduces metals in cold form to slit coils in specified widths.

## Publicity Agents Named

Ketchum, MacLeod and Grove, Inc., has been appointed to handle public relations activities for The American Society of Mechanical Engineers, it was announced by C. E. Davies, secretary of the 39,000-member organization.

STORAGE TANKS
LPG, Anhydrous Ammonia
and Gasoline

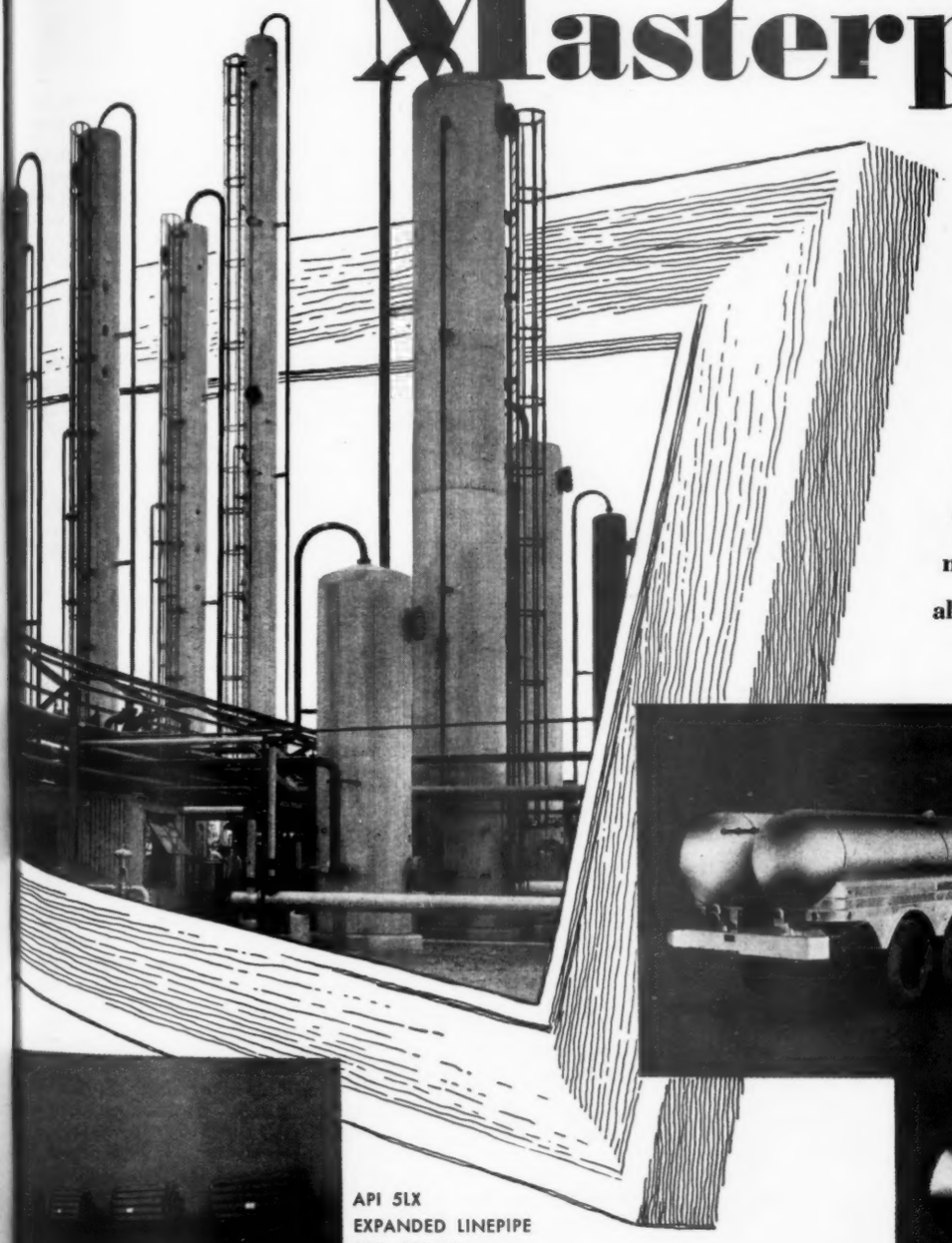
LPG and
Gasoline
FUEL TANKS

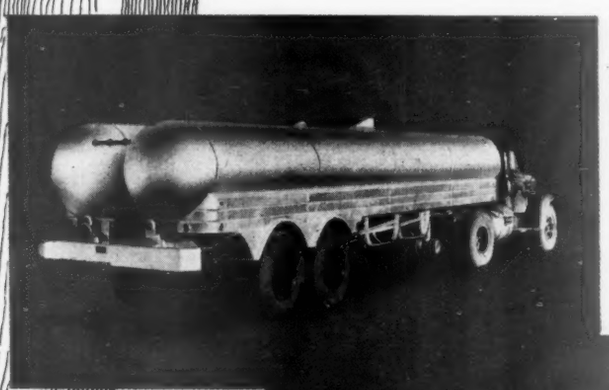
...rom the Great Southwest...

ES REFINERY VESSELS

# Masterpieces of steel construction

**A few examples of production and custom steel fabrication, designed and produced by the facilities of Master Tank & Welding. For any requirements, write, wire or phone. We also warehouse steel plate.**





LPG and
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Ammonia
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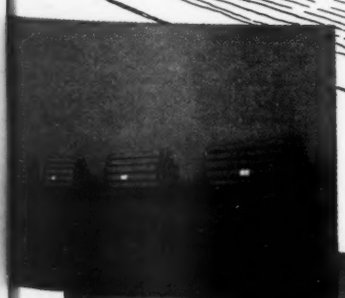
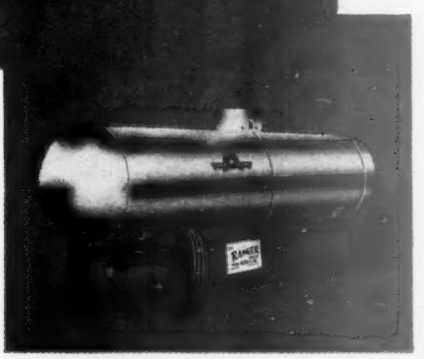
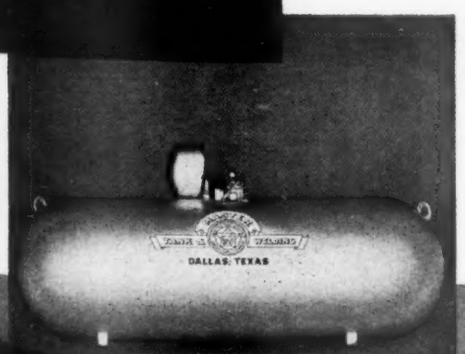


API 5LX
EXPANDED LINEPIPE
20" - 30" Diameter



ANHYDROUS AMMONIA SYSTEMS

LPG
DOMESTIC
SYSTEMS

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Better PIPE TOOLS

CHAIN TONGS

"Reversible," "Standard" and "Ideal" types in all sizes. Jaws are drop forged from special steel, are carefully milled, heat treated, hardened and tested. The *Handles* are forged spring steel. The *Chains* are proof-tested to ⅔ catalog strength (1,200 lb. to 40,000 lb.). "Reversible" Jaws give double jaw life. "Standard" Jaws have extra bearing on the handle and forged-in chain guides. The "Ideal" Tongs have V shaped teeth for a sure grip on irregular shapes — fittings, etc.

Write for Catalog

ARMSTRONG BROS. TOOL CO.
"The Tool Holder People"
5231 W. ARMSTRONG AVENUE • CHICAGO 30, ILL.

# TRADE PERSONALS

O. A. Johnson

L. Lyles

D. C. Vernon

H. P. Richardson, Jr.

**O. A. "Jack" Johnson** has recently been sent to the West Texas area as sales representative for American Iron and Machine Works. Before coming to American Iron, Johnson represented Security Engineering Division, Dresser Industries and the Pure Oil Company serving in a sales capacity for both companies.

**LeRoy Lyles** will represent American Iron in the Southwest Louisiana territory and will reside in New Iberia. Lyles was formerly with the Tuboscope Company in the Louisiana and Oklahoma areas.

**Harry N. McDow** has been named sales representative for Oil Center Tool Company, with headquarters in Denver, Colorado. McDow was formerly a salesman for Gulf Supply Company and Rockwell Manufacturing in Corpus Christi.

**Daniel Cooper Vernon** has joined Wedgeplug Valve Company as sales coordinator. Wedgeplug is an affiliate of Stockham Valves and Fittings. Vernon's job — a newly-created one — will be to co-ordinate the sale of Wedgeplug valves with Stockham products.

**H. P. Richardson, Jr.** has rejoined Oil Base, Inc., after six months duty with Halliburton Oil Well Cementing Company. He will serve as a sales engineer in the Mid-Continent area working out of Duncan, where he makes his home. Richardson received a B.A. in chemistry at Texas Christian University.

**W. E. Swafford** has been appointed sales engineer at the Lake Charles, Louisiana branch of the McCullough Tool Company.

J. E. Heuser

P. L. Veltman

R. G. Glotzner

**J. E. Heuser,** engine division sales manager of the Le Roi Company, subsidiary of the Westinghouse Air Brake Company, of Milwaukee was elected president of the Internal Combustion Engine Institute.

Other officers elected were: vice-president, **B. G. VanZee,** chief engineer, Minneapolis-Moline Company; secretary, **H. W. Smith,** consulting engineer engine division, Caterpillar Tractor; and treasurer, **J. D. Cook,** secretary-treasurer, Hercules Motor Corporation.

**P. L. Veltman** has been advanced to director of research and development from manager of the Curtis Bay (Baltimore) Laboratories, Davison Chemical Corporation. **Ralph E. Hope,** formerly manager of research engineering, has been made an assistant director, his duties including management of the laboratories. **L. L. Baral** has succeeded him as manager of research engineering. **W. K. O'Loughlin** has also been named an assistant director. He was formerly manager of the development department, in which position he is succeeded by **O. D. Myrick.**

**Edwin M. Glocker,** formerly staff assistant to Dr. Bachman, has been made manager of the research statistics department, a new post. **Luther O. Young** is manager of the application research department, another new post. Dr. Bachman's staff assistants are **C. D. Helm** and **A. J. Antonious.**

**Raymond Glotzner** has been appointed oil field sales engineer for the Armite Laboratories, covering all domestic sales and engineering according to John H. Armington, president. In addition to handling the line of Armite anti-seize compounds, Glotzner will also handle the oil industry sales of Custanite, the new grip coating, manufactured by the Custanite Corporation and their line of "Flex-Flo" safety hammers.

**W. G. Skinner** has been named district machinery manager for Mid-Continent. Skinner was formerly sales engineer for Mid-Continent in Midland, Texas, and has worked for the organization in Edmond and Pauls Valley, Oklahoma. Skinner attended the University of Oklahoma, where he received a Bachelor of Science degree in mechanical engineering During the war he was with U. S. engineers.

## Trade Personals

R. E. McBurnette

P. I. Bediz

**R. E. (Mac) McBurnette** has joined W. C. Norris, Manufacturer, Inc., as Tulsa salesman. For the past four years McBurnette represented the Axelson Manufacturing Company in Kansas with headquarters at Great Bend. He was graduated from Oklahoma A & M.

**Pertev I. Bediz** has been appointed vice president of Century Geophysical Corporation of Canada. Bediz attended the University of Istanbul, Turkey, and is a graduate of the Colorado School of Mines. He was awarded a teaching fellowship at Massachusetts Institute of Technology where he did graduate work on his doctorate degree.

**H. R. Powers** has been named general manager of Koehring Company of California, the parent firm, Koehring Company, Milwaukee, Wisconsin has announced. He was domestic sales manager of the LeTourneau-Westinghouse Company, Peoria, prior to accepting the post. He will be in charge of all operations at the West Coast Koehring subsidiary and is taking up his new duties immediately.

**Faustin J. Solon, Jr.,** vice president of Glass Fibers, Inc., has also been appointed assistant to the president of the company in charge of public and trade relations. In his new position, Solon will have full responsibility for development of the trade relations department, a new marketing function with the company. Solon has been with Glass Fibers since 1947 in merchandising, sales and advertising capacities.

**Charles Leroy Fox** has been appointed drilling mast-sales engineer, Emsco Manufacturing Company. Prior to joining Emsco, Fox was president of the Fox Diamond Derrick Company, Fort Worth, Texas.

**W. D. Lease,** formerly in charge of research and development for Athey Products Corporation, has been appointed manager of sales promotion. In this newly created position, Lease will direct the activities of advertising, sales development and sales training. **A. R. Langton** will continue as export sales manager, **A. T. Marchuk** as domestic sales manager, and **E. L. Peterson** as advertising manager. After receiving his degree from Armour Institute, he has been associated with Athey Products as works engineer, district representative in the central and mid-western states, and manager of research and development.

**Harry B. McClure** has been appointed president of Carbide and Carbon Chemicals Company, a division of Union Carbide and Carbon Corporation. McClure succeeds **Dr. J. G. Davidson** who becomes chairman of Carbide and Carbon and a member of the appropriations committee of Union Carbide. Davidson is also a vice president of Union Carbide and Carbon.


Oil Field Dozing

9X

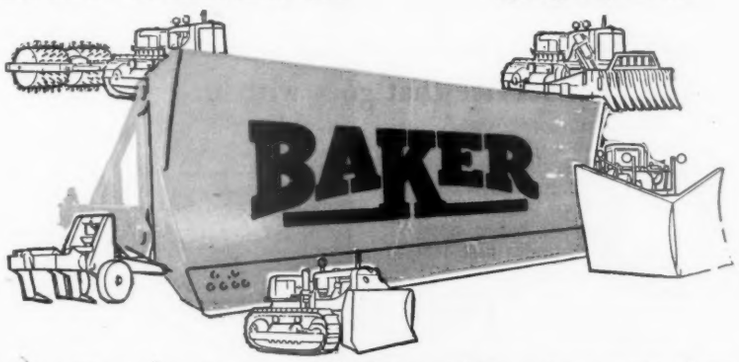
Blade—46" high, 96" wide (highway "legal" width).
Weight—approximately 21,450 lbs. Drawbar hp.—72.

OIL FIELD ACCEPTED . . . the new Baker 9X no-pushbeam Dozer, a powerful, compact 8 ft. Dozer that *moves*—on the job and over the road!

Load it on standard-width truck or trailer and haul it anywhere—over any highway—*legally.* Put it to work on any job—fire walls, slush or salt water pits, or any other field dozing—and watch it sock down deep and *fast,* down to 13" below ground-level with a *steeper* angle of approach. Pour on the power and see the famed Baker "roll-action curve" boil the dirt high. Flick the fingertip control and up comes the blade—*fast*—up to 37" above ground level. No loss of traction—bulk of 9X's weight "stands on the blade," for both tractor and dozer frame are *one integral unit.*

If you haven't seen the new 9X in action, contact your Baker, A-C Dealer today—ask for a demonstration, or write for Bulletin No. 896-B.

THE BAKER MANUFACTURING COMPANY
Springfield, Illinois




**Baker—The most *versatile* line of tractor attachments**




To obtain more information on products advertised see page E-61

193 94

SAFE

97 109

NUMBERS

203 375

31 142

55

# For Emulsion Breaking Efficiency

EVERY Visco formula means *dry oil* to the man who uses it! These, and a host of other formula numbers mean emulsion breaking safety that eliminates tank rolling, assures minimum B. S. & W. in *every tank, every time.*

Make a 90-day test of the formula your Visco Service Man recommends. Odds are high — from actual count — that once you see Visco results, you will not be without your Visco formula, or the twenty-four-hour-a-day Service that goes with it.

*For Action*

*on your 90-day test . . . or on a specific emulsion breaking problem: Call Houston, CAPITOL 7300, collect.*

**VISCO PRODUCTS COMPANY**
**INCORPORATED**
**2600 Nottingham at Kirby**
**Houston 5, Texas**

*Visco*®

**. . . CONSISTENTLY EFFICIENT DEHYDRATING AND DESALTING CHEMICALS**

# New Machinery and Supplies

**Use reply card to procure promptly complete information and prices of products described here in brief.**

***Circle corresponding letter or letters on reply card***

### (A) GEOPHONE CLIP

Vector Manufacturing Company is now manufacturing the C-5 "Gator" geophone clip which helps geophysical crews speed up time in making geophone connections. For use with the Vector split spring cable takeout, the C-5 clip is designed to minimize costly field maintenance as well as assist operators in obtaining more accurate records. Its patented construction offers complete resistance to moisture, positive polarity identification and freedom from breakage and subsequent field repair. Corresponding slots of different size on both the takeout and geophone clip practically eliminate the possibility of error in making quick connections.

Circle letter (A) on reply card.

### (B) MUDLINE VALVE

A new alloy steel mudline valve for the oil drilling industry—the Mudwonder—which stops sanding-up, reduces maintenance and "down-time"; yet, is easier and faster to operate, has just been announced by Edward Valves, Inc., a subsidiary of Rockwell Manufacturing Company. Secret of the Mudwonder is its simple, self-aligning steel gate which is separate from the stem and its resilient buna-N seat insert that make "drop-tight" closures easy. The mudline pressure rather than stem pressure is responsible for the seal.

Circle letter (B) on reply card.

### (C) VALVE LUBRICATION AID

A new large button head coupler for use with Rockwell high pressure lubricant hand guns and bucket pumps has been introduced by Rockwell Manufacturing Company. Most important feature of the new coupler is a positive shut-off device to stop all extrusion of lubricant from the coupler immediately after removal from the fitting, thus solving an important field problem.

Circle letter (C) on reply card.

### (D) PICK-UP

Cushman Motor Works, Inc., manufacturer of motor scooters and light hauling vehicles, announces that it has gone into full scale production on an entirely new 1954 model pick-up Truckster. The new Truckster is designated as the 780. The 780 Truckster represents new development in the light, three-wheel vehicle field in that it uses a shaft drive, automotive type differential, a transmission with three speeds forward and one reverse, plus a rear-mounted pick-up style body.

Circle letter (D) on reply card.

### (E) ENGINEERED KIT

J&S Carburetor Company announces a special engineered kit for converting Chevrolet cars and trucks, and GMC trucks to LPG (butane-propane). The kit is designed for quick, easy installation and requires no mounting bracket, drilling of holes, or plumbing to obtain water circulation. The kit is expected to make it possible for fleet operators themselves to convert their cars and trucks without need of an LP-gas carburetion expert, as simple, illustrated instructions are provided with kits. The unit is bolted onto the front of engine block in place of thermostat housing, and full flow of hot water is obtained even in coldest weather, for vaporization of the LPG.

Circle letter (E) on reply card.

### (F) SHOVEL

After a full two years of research and engineering plus another year of field testing, American Hoist announces it has its new Model 750 shovel in full production. The new shovel is rigged for all purpose work—crane, clamshell, dragline, shovel, and backhoe. As a shovel the machine is rated at 1½ yd with backhoe designed for the same capacity. Thirty-five tons is the machine's rated capacity as a crane, and it will handle a two yard clamshell or dragline.

Circle letter (F) on reply card.

### (G) KON-KAVE BOW

The centering ability of the B and W Latch-On centralizer has been greatly increased with the introduction of the kon-kave bow, B and W Inc. reports. The curved cross-section of each bow provides greatest strength and most resistance to deformation or breakage. Higher quality spring steel is hot formed by drop forging, to exact specifications and the normal heat treatment to develop the full strength of the alloy spring steel is supplemented by a later special heat treatment that removes stresses caused by welding the bows to the end collars.

Circle letter (G) on reply card.

### (H) PRECISION LEVEL

As precision alignment is essential to exact duplication of parts and is also an important factor in preventing excessive machinery wear, the new Lufkin master precision level, Number 59, has wide application in the metal-working industry — in machine shops, inspection departments, tool rooms, and millwright departments. This precision level gives extra accuracy. Ground and graduated vial is of 10-second accuracy, with one division equaling .0005 of an inch per foot. The special alloy base is less affected by temperature changes and the top plate is made of special non-conductive insulating material. Lufkin Rule.

Circle letter (H) on reply card.

### (I) TRUCK CABS

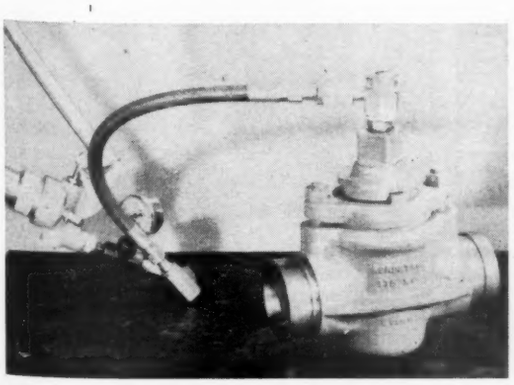
A new, roomier, all weather cab for the Gar Wood 75 series standard and heavy duty ¾-yd excavators and 20-ton truck crane has been announced by Gar Wood Industries, Inc. With emphasis on operator convenience, comfort and maximum safety, the new cab features extruded rubber-mounted windows. Of the same type construction used in truck cabs, these new windows afford complete moisture and weather protection. In addition, the extruded rubber mounting insures more rigid construction and facilitates replacement of glass. For hot weather operation, the window assembly easily folds back.

Circle letter (I) on reply card.

### (J) PRESSURE GAGE

A new design in pressure gage construction has been announced. Models may be obtained with a dial diameter as small as 1 in. and a total weight of less than 2 oz. Their ability to survive severe shock has been tested to withstand a 50 G shock test and vibration tests at 8 Gs — 20 to 500 cycles per second (variable frequencies). Pressure ranges run from 0 to 100 up to 0 to 60,000 graduation readings. These gages manufactured by Designers for Industry.

Circle letter (J) on reply card.



Rockwell's valve lubrication aid.

Glaser's pressure gage

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Chief Engineer H.F.D. stated, after Nicholsons replaced mechanical traps in his plant: "Saving in steam waste cut our fuel cost at least 10%. Yet application temperatures were up 30°-40°. And relief of all air binding effected faster warm-up."

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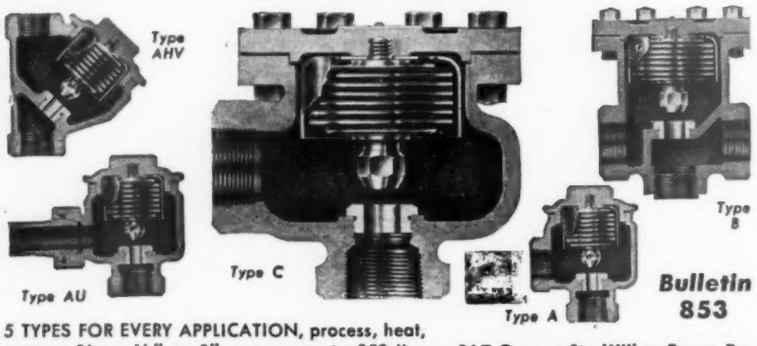


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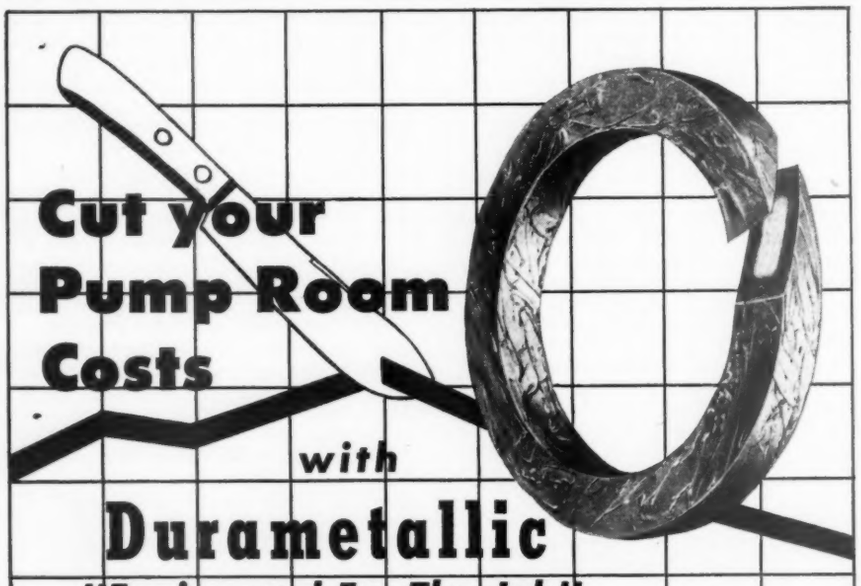

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## New Equipment

### (K) CENTRIFUGAL PUMP

Chempump Corporation has announced a total enclosed pump that cannot leak.

Among the advantages are—no leakage or contamination of fluids—completely contains expensive, toxic, corrosive, or volatile fluids — protects personnel and equipment. Maintenance with Chempump is practically non-existent, the company claims. As there is no stuffing box or shaft seal, 90 per cent of centrifugal pump difficulties are eliminated. Chempump is self-lubricating.

Circle letter (K) on reply card.

### (L) FLOW CONTROL

A new formulation of general purpose Styron (Dow polystyrene) developed by The Dow Chemical Company is expected to open new markets for polystyrene by providing molders with better control over the flow of plastic in the mold. The new material, known as Styron 688, flows fast and evenly throughout the mold, an important consideration in the injection molding of many intricate or thin-walled parts or deep sections.

Circle letter (L) on reply card.

### (M) INDUCTION MOTORS

The Allis-Chalmers Manufacturing Company's complete new line of alternating current squirrel cage induction motors in frame sizes 326 and smaller were shown to a group of editors and manufacturers during a two-day meeting, recently at the company's Norwood, Ohio, plant.

In the absence of P. F. Bauer, general manager of the Norwood Works, F. J. Geiger, manager of the electrical section, pointed out that the new design of frame sizes up to and including 326 follows the newly established NEMA standards, which mark the first major change in frame reassignment for these sizes in 25 years.

Allis-Chalmers showed their new open and totally-enclosed (fan-cooled and explosion-proof) models during the meeting. Geiger outlined the history of the NEMA rerate program.

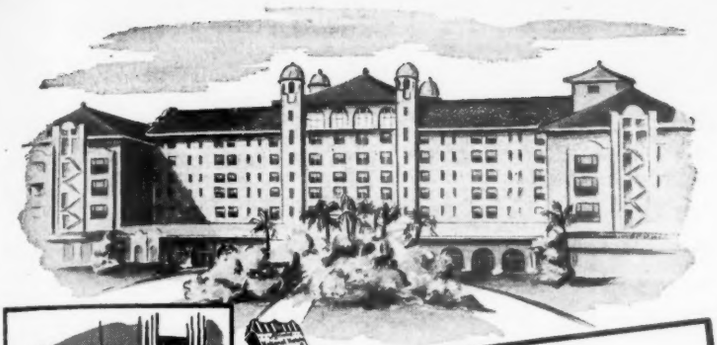
Circle letter (M) on reply card.

### (N) OSCILLATOR

The MB-1 oscillator, with an SIE Geophysical Microvolter, was recently developed by Southwestern Industrial Electronics Company. Completely portable

and battery powered, it provides signal frequencies from 2 to 20,000 cps ac or dc pulses at calibrated amplitudes of 1 microvolt to 1 volt. The attenuator can match load impedances from 10 to 500 ohms.

Circle letter (N) on reply card.



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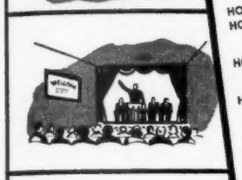

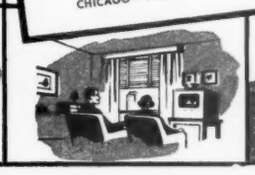

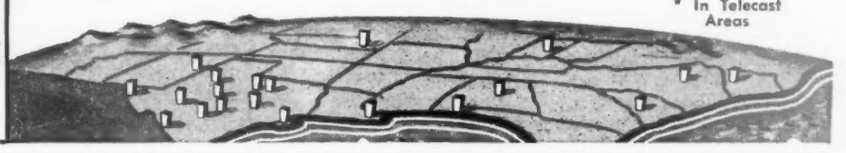

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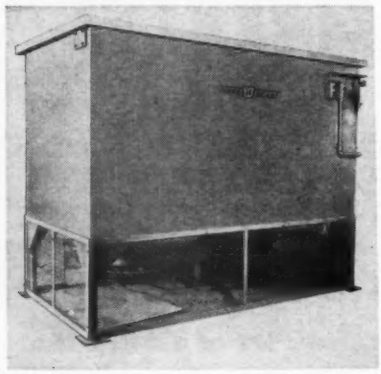
## New Equipment

### (O) PARTS CLEANING MACHINES

Every refinery of any size has a parts reclamation department or section, and these cleaning units are potentially desirable in every refinery. Smaller plants often go about parts cleaning, such as valves,



fittings, etc., in a rather haphazard manner. Larger plants spend more money and have a more efficient crew for the purpose. Having such a systematic unit handy might well induce refiners, small and medium size, to carry on reclamation routines that now do that haphazardly if at all. New models of Turbo-Blast parts cleaning machines have been announced by Storm-Vulcan, Inc.

Circle letter (O) on reply card.

### (P) LEATHER PRESERVATIVE

A new silicone leather preservative introduced by Dow Corning Corporation keeps work shoes and leather equipment soft and pliable despite the deteriorating influences unavoidable in many industrial plants. Known as Shoe Saver, the material is a clear fluid which may be easily applied with a soft cloth or swab. Like other silicone-based treatments for textiles and masonry, Shoe Saver is a water repellent, not a waterproofing agent.

Circle letter (P) on reply card.

### (Q) RIVER CLAMP

The Lloyd Metal Foundry Company has announced an addition to its present line of river clamps. This newest clamp is technically known as a "drag-type hinged clamp weight". As the name implies one advantage of this new clamp weight is the streamlined shape that makes it suitable for a drag operation. The working principle is somewhat similar to the river clamp weight recently placed on the market by Lloyd in that it can be quickly applied with a minimum of effort. The drag-type hinged clamp weight is in one piece and, therefore, can be handled easily. One each side of the drag-type hinged clamp weight are lifting bars built into the clamp to which a sling may be attached.

Circle letter (Q) on reply card.

### (R) SILENCERS

A new line of high velocity steam and air exhaust silencers has been developed, by the Burgess-Manning Company. The new line is known as Series "ADS" acoustic discharge silencers. They are designed to eliminate high and low frequency noises caused by high velocity discharge from steam and air devices. The new silencers operate on the Burgess-Manning snubbing principle and employ especially designed acoustic reactance chambers.

Circle letter (R) on reply card.

### (S) BLOWOUT PREVENTER

Shaffer Tool Works recently announced the Type 51 combination rotating blowout preventer and stripper, which is used for blowout protection on such operations as slim-hole drilling, work-over jobs, drilling-out operations, repair work and a wide range of similar drilling and production applications through casing diameters of 10¾-in. and smaller.

The Type 51 is similar to the larger Type 50 preventer which is used on drilling operations to provide continuous and automatic pressure protection while the drill string is in the hole.

Circle letter (S) on reply card.

### (T) ROTARY CUTTER

The Dearborn rotary cutter, said to be capable of a wide range of cutting jobs from roadside mowing to clearing underbrush, has been added to the Dearborn equipment line, Ford Motor Company. This heavy duty, five-foot rotary blade mower shreds as well as cuts so that grasses are not smothered by weeds and brush. A removable deflector shield is mounted under the blade hood to insure even distribution of cut material.

Circle letter (T) on reply card.

### (U) FILTERS

Winslow full-flow filters with controlled pressure elements will be standard equipment on the Hall-Scott 590 series of gasoline and LPG engines, according to William Nostrand, Winslow vice president. The new Hall-Scott has more than 200 hp with less than 1300 lb weight and will be used in a wide range of applications.

Circle letter (U) on reply card.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Remove grease, oil, wax and sludge deposits from valves, pumps, cylinder blocks engine parts, drill bits and all production, processing and transportation equipment in a fraction of time required by soak methods. Impellers create a vigorous scrubbing action. Solution is heated with steam, fuel oil, natural or manufactured gas . . . thermostat control for efficiency and economy. Turbo-Blast cleans thoroughly . . . including recessed areas . . . eliminates hand-brushing. Performance facts available.

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# Trade Literature

**Publication will be sent free.**

### (V) OXYGEN ANALYSIS

A new bulletin titled "Chemical Applications of Industrial Gas Analysis" emphasizes the importance of industrial gas analysis in the production of manufactured gas, inert purging operations, and safety applications where oxygen is the principal contaminant. Through accurate and continuous gas analysis, improved product quality and greater profits can be realized. This bulletin — No. AD-610, published by Arnold O. Beckman — outlines a recommended list of equipment.

A second Bulletin (No. 702) illustrates and describes the operation of a sampling system for the dry gas samples encountered in many chemical applications.

Circle letter (V) on reply card.

### (W) FLAME CUTTING

A new 12-page booklet entitled, "Advanced Automatic Flame Cutting for Machinery Weldments," is being offered by Air Reduction. Reprinted from The Welding Journal, this article relates how the Marion Power Shovels Company converted from castings and riveted structures to weldments and discusses the problems involved in making this change. It tells how, using the electronic tracer, to improve flame-cutting flexibility and increase production capacity while reducing the cost of flame-cut parts and steel plate items for these weldments.

Circle letter (W) on reply card.

### (X) PIPE INSULATION

Mono-Kover, the new lightweight one-piece pipe insulation is the topic of a four page, three color, bulletin, published by Baldwin-Hill Company. The description of the ease with which Mono-Kover may be applied is accompanied by photographic illustrations. Other characteristics of Mono-Kover described are its thermal resistance, permanence, resiliency, non-corrosive properties, and lower applied cost.

Circle letter (X) on reply card.

### (Y) GAS SERVICE FITTINGS

A new booklet titled, "How To Make Gas Connections Safely," has just been released by Mueller Company. Composed of reprints of two-page, two-color advertisements that Mueller Company ran during its 1953 campaign, the booklet shows pictorially the step-by-step procedure for installing gas fittings and line stopper equipment in a gas distribution system. Fittings and stopper equipment are installed under pressure, without loss of gas.

Circle letter (Y) on reply card.

### (Z) CASING TONGS

Recently published is a 2-page color leaflet depicting the Web Wilson deep face casing tongs, which were introduced officially at the 1953 International Petroleum Exposition. The new "ADF" casing tongs is said to retain all of the famous Web Wilson tong features, in addition to new deep face jaws. Using only four interchangeable lug jaws the "ADF" fits casing sizes ranging from 95/8 in. to 143/8-in. od.

Circle letter (Z) on reply card.

### (AA) POWER MACHINES

Beaver Pipe Tools, Inc. has recently produced a new, 16-page power machine catalog. Attractively printed in green and white, Beaver's new catalog covers selling features, dimensions, operating capacities, users, ordering specifications, dies available and accessories for five pipe machines and power drives, plus Beaver's new "55" Universal nipple chuck.

Beaver Models "A," "B," "E" pipe and bolt machines and Beaver models "D" and "C-1" portable power drives are fully described and shown in color.

Circle letter (AA) on reply card.

### (AB) INDUSTRIAL EQUIPMENT

The complete line of Allis-Chalmers Manufacturing Company industrial equipment is pictorially described in the newly revised general line catalog "Presenting the Allis-Chalmers Line." The catalog has been expanded to 36-pages to include illustrated information and data on HD-15 crawler tractor now available with a choice of two drives — standard transmission or hydraulic torque converter.

Circle letter (AB) on reply card.

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**Portland, Ore.**—Earl H. Jones & Co., 1233 NW 12th 9ve.
**Richmond, Va.**—P. C. Abbott & Co., 15 E. Franklin St.
**San Francisco, Cal.**—Earl H. Jones & Co., 1150 Folsom St.
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## Trade Literature

### (AC) HYDRAULIC JARS

A comprehensive 56-page catalog showing major overshots, hydraulic jars, line wipers, and other specialties manufactured by the Bowen Company of Texas, is now available. Illustrative drawings showing construction, operation and use of all the tools, as well as specific recommendations for use and service together with price list, are included.

Circle letter (AC) on reply card.

### (AD) UREA PROCESS

Montecatini's unique "ammonia-saturated" process for producing urea is the subject of a new eight-page booklet published by The M. W. Kellogg Company. Kellogg is the exclusive licensor of this process in the United States. This is one of several new chemical processes now available through Kellogg's chemical process division. The process is a partial recycle system that utilizes an unusual expansion-condenser unit to recover nearly 75 per cent of unreacted ammonia and carbon dioxide.

Circle letter (AD) on reply card.

### (AE) POWER TRANSFORMER

Standardization of core form power transformers is discussed in a new 40-page booklet available from the Westinghouse Electric Corporation. This booklet relates developments in construction, materials, and operation of Type SL power transformers to the benefits the user derives from standardization of the various components. Besides covering construction and operation characteristics, this booklet also describes various standardized processes used during manufacture of a Type SL power transformer.

Circle letter (AE) on reply card.

### (AF) FLOW ALARM

The Flow-Gard, developed by Brooks Rotameter Company, was designed to meet the demand for a fail-safe, highly sensitive alarm device for rotameters, manometers, and similar process instruments in order to provide dependable operating stability, the company reports. The unit offers wide range of sensitivity for both high and low flow signalling and is the only alarm system available which can operate accurately in conjunction with spherical floats as small as 3/32-in. permitting use on smallest rotameter capacity ranges. Complete specifications, operating details, and application data are given in the Brooks Bulletin No. 165.

Circle letter (AF) on reply card.

### (AG) ENGINES

Engines powered for any oil-pumping job are featured in a new two-color booklet, *The Power Behind the Pump*, available from Caterpillar Tractor Company. Pictures of Cat engines on oil-pumping jobs and testimonials by their owners are portrayed throughout the 8-page booklet. The power line, a chart, gives the maximum, rated and continuous hp output of each model of Cat engine, and map of North America showing Caterpillar factories, parts depots, dealer outlets.

Circle letter (AG) on reply card.

### (AH) SWITCHES, ACTUATORS

A new 4 page catalog (Catalog No. 74) is now available giving complete information on ultra-small "type V3" precision snap-action switches and auxiliary actuators by Micro-Switch, a division of Minneapolis-Honeywell Regulator Company. The Micro-Switch line of "type V3" switches (postage stamp size) has the highest electrical rating, for the overall size, of any snap-action switch available, the company claims. Three of the 15 switches cataloged conform to Military Specifications MIL-S-6743.

Circle letter (AH) on reply card.

### (AI) FUELING UNIT

A four-page bulletin covering a fast fueling unit for tractors, trucks, and engines using LPG, is now available. The material covers a new Model GG 196 Viking built pump with capacity of 10 gpm at 1750 rpm and driven by a ½ hp explosion proof motor. The whole unit weighs approximately 145 lb and is mounted on a steel base. Installation method, performance curve and specifications are included. Viking pumps are distributed on the Gulf Coast by Southern Engine and Pump Company.

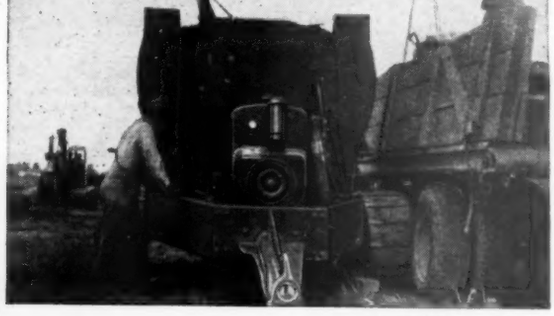
Circle letter (AI) on reply card.

### (AJ) TRENCHER

A new 8-page, 2-color bulletin on the Cleveland Model 140 trencher has been issued by The Cleveland Trencher Company. Special features of Model 140's design and construction are fully described in the bulletin. Recent action photos illustrate various job applications within scope of the 140. Bulletin contains complete dimensions and specifications including table of digging wheel and crawler speed combinations available in Cleveland's famous multi-speed transmission and table of standard and maximum cutting widths.

Circle letter (AJ) on reply card.


# WISCONSIN-POWERED C-R-C "SP" DOPE KETTLE *Solves* Difficult Power Problem



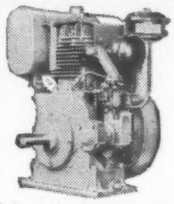
Power TO FIT THE JOB

Power TO FIT THE MACHINE

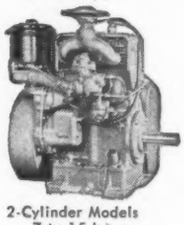
Towed directly behind a Traveling Pipe Coater, this Dope Kettle, made by Crutcher-Rolfs-Cummings, Inc., transfers liquid tar to the coating machine by means of a rotary pump. A Model VF4D Wisconsin 4-cylinder Heavy-Duty Power Unit provides dependable power for operating the tar pump, two fuel pumps, and two blowers for feeding air and fuel to the burners.

Dust and fumes that would ordinarily settle in radiator fins of a water-cooled engine, creating an insulation that causes engine to heat, do not affect the highly efficient, dependable AIR-COOLING System of the Wisconsin Engine because the powerful air blast keeps the dust moving. Just another point in favor of Wisconsin Heavy-Duty Air-Cooled Engines for oil field service.

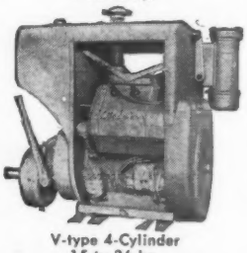
The Wisconsin line includes 4-cycle single cylinder, 2- and 4-cylinder models in a complete range from 3 to 36 hp. All models can be equipped to operate on kerosene, natural gas, butane or propane, utilizing the most readily available and economical fuels.



4-Cycle Single Cylinder 6 to 9 hp.



2-Cylinder Models 7 to 15 hp.



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# BOOKS ★

**Construction Methods and Machinery,** *F. H. Kellogg. Prentice-Hall, New York. Price, $10. Pages, 415.*

The "new look" that is being acquired by the construction industry is comprehensively and ably covered in this volume by the author's application of the principles of industrial engineering to construction planning, estimating, equipment selection, and cost control. The user of such techniques as process charts, time studies, and graphical methods are explained and applied to construction problems. Through study and application of these techniques, the contractor, engineer, or architect can greatly improve performance, cut costs, and streamline operations. In the first three chapters, an entirely new approach is used in discussing organization and planning, control, and equipment economics. The machinery section in four concise and complete chapters covers power, transportation, hoisting and conveying, and pumping. Construction methods and problems are more than adequately covered in the remaining seven chapters, including site preparation, earthworks, rock excavation, foundation treatment, aggregate preparation, concrete, and structural erection. The tables section contains a round-up of information that would be difficult to find elsewhere. Engineers and construction men in any field will find the book an excellent reference and a source of ideas.

**Let Freedom Ring,** *by Campbell Osborn. Published by The Inter-Nation Company, Suite 601 Hino Building, 4 Tori 2-Chome, Nihonbashi, Tokyo, Japan. Pages, 211. Price, $2.00.*

The author worked for E. W. Marland during the hectic oil boom days of Oklahoma. His home was in Ponca City, near the famous 101 Ranch. In this book on Oklahoma he has written an entertaining, and intimate history of the great and not so great who lived in early Oklahoma. Many incidents throw a new light on the early beginnings of the state and especially of the oil industry, which played a leading role in Oklahoma economics.

**Fundamentals of Reservoir Engineering** *by Dr. John C. Calhoun, Jr. University of Oklahoma Press, Norman, Oklahoma. Price, $6.00.*

Discussion of the behavior of fluids in reservoirs, study, and treatment of rock properties, fluid flow in porous media, reservoir energies and forces, and estimation of oil in place and oil production.

**Il Meraviglioso Mondo del Petrolio,** *Fernando de Mattia, Edizione Sedic, Rome, Italy. Pages, 231.*

The Italian oil industry is fortunate in having a new volume that reviews briefly the history of world oil operations before presenting a picture of the present situation. "Il Meraviglioso Mondo del Petrolio" by Fernando de Mattia is an interesting account of the "Marvelous World of Oil," beginning with legends of ancient times in Imperial Rome, in the New World, and in medieval and modern Europe. Then Mattia goes into the U. S. history of the oil industry beginning with Drake.

A more valuable contribution is a review of world oil activities along with a study of production, refining and transportation.

The appendix carries references about equally divided among four languages. Mattia has a rich fund of information as a base for his volume.

Excellent illustrations are contributed almost entirely by American oil companies. Typography and printing are exceptionally fine in the book.

**Oil and Gas Rights,** *Victor H. Kulp. Little Brown and Company, Boston, Massachusetts. Pages, 916. Price, $15.*

This up-to-date report on the legal aspects of everyday problems that arise in the normal conduct of operations in the oil business contains also a 1954 pocket supplement to "American Law of Property." It includes a complete treatment of leases, pipe lines, conservation, taxation, and others. The book provides step-by-step coverage of the provisions of the oil and gas lease, which includes a discussion of such topics as implied covenants, as well as practical suggestions on drafting.

**Glossary of Terms used in Methods, Time Study and Wage Incentives.** *Published by the Society for Advancement of Management, 74 Fifth Avenue, New York 11, N. Y. Price, $1.00. Pages, 32.*

This handy 4 by 9-in. manual, printed on tough, long-wearing paper, is an ideal and authentic reference on the terms and expressions used in business and management. Ninety-three management leaders (and members of the Society for Advancement of Management) spent four years in compiling the 332 definitions that appear in the Glossary and the terms and expressions are defined on the basis of their interpretation by the greatest number of experienced people using them professionally and successfully.


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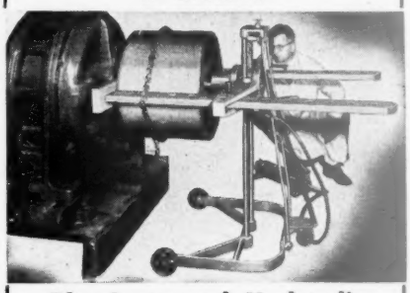

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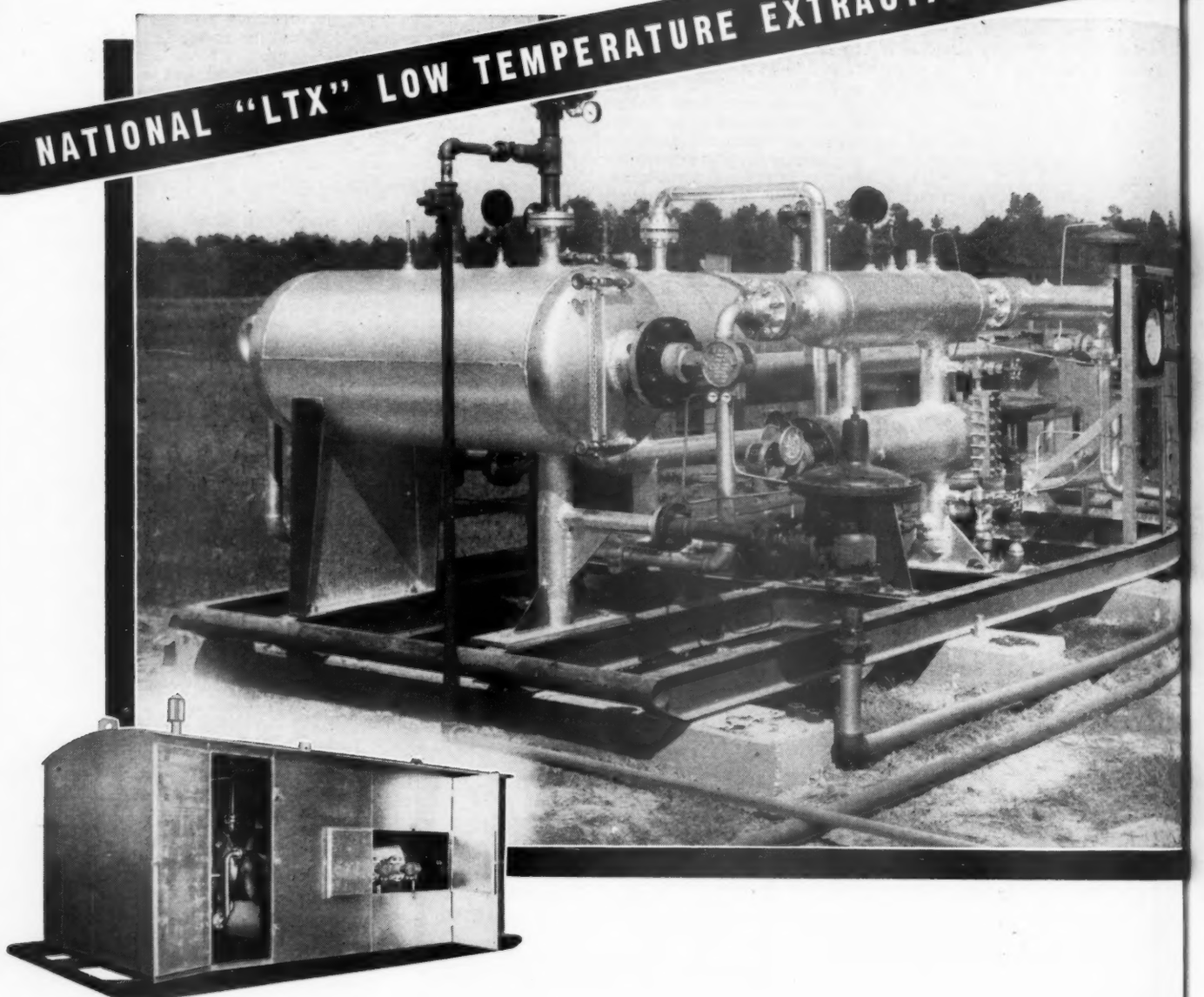

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